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ICT AND KNOWLEDGE ECONOMY AS AN APPLIANCE FOR ACHIEVING ECONOMIC GROWTH IN NIGERIA

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Abstract
Economic growth theories predict that economic growth is driven by investments in ICT. This study examined the relationship between ICT, Knowledge economy and economic growth. The Engle-Granger (1987) two-step modelling (EGM) procedure involving: cointegration analysis and error correction of parameter estimates were used. It was discovered that the level of mobile phone subscription has a significant effect on value added by labour in the long and short run. A 0.03 percent increase would result in a 1 per cent increase in the growth of the value-added by labour in Nigeria in the long and short run. The level of internet subscribers is positively signed but not pronounced and also, the growth of education which represents knowledge economy has significantly affected the value added by labour in the country. However, it shows that if education output decreases, the value added by labour increases at 0.07 percent in the long and short run. The result is not in line with the belief that education is the bedrock of technology. The study concludes that Education institutions should be encouraged to embrace ICT, and underscore the role of R&D capital stock in the country.

Keywords: ICT, Knowledge Economy, ECM and Internet subscribers.

Introduction
Over the past fifteen years, the progress and development of ICT have affected all segments of the economy in such a way that no one can imagine any business

process which does not rely on the use of ICT. World Bank surveys of approximately 50 developing countries as reported by [1] suggest that firms using ICT see faster sales growth, higher productivity, and faster employment growth. The use in education can play a crucial role in providing new and innovative forms of support to teachers, learning and research & development especially in developing countries like Nigeria. A knowledge economy places less emphasis on physical labour and more emphasis on research, discovery, and applying minds to create effective processes, it is a scheme of production and consumption that is based on scholarly capital. It typically represents a large component of all economic activity in developed countries. According to [2], when ICT is implemented correctly, software in the classroom, for example, can allow students to learn at their own pace and tablets can help children develop important digital skills and computer know-how that they'll need to succeed in a knowledge-based economy. Furthermore, a growing body of research supports that ICT is a powerful tool for education in any country.

Attempts to ensure sustainable economic development and poverty reduction of most nations, usually involve the development of the education sector. Adam Smith referred to new layers of specialists who are men of speculation and who make important contributions to the production of economically useful knowledge. The Industrial Revolutions in Asia, America and Europe, generally and specifically, have been premised on technological breakthroughs. During the late 1990s, Information and Communication Technology (ICT) was the largest contributor to growth within capital services for both Canada and the United States [3]. Similar trend has been observed with the economic development of China, Korea, Taiwan, India, South Africa, and other emerging economic powers [4].

In Nigeria, information and communication technologies (ICT) have been recognized as one of the major factors that reduce poverty and create innovations that is why the Federal Government of Nigeria embarked on an aggressive drive towards the provision of more efficient services in the nation through its privatization and deregulation policies in the ICT subsector at the wake 2000. The policy led to the establishment of National Telecommunication Policy in December 2001which gave way to the licensing of telecommunication service providers and the adoption of Global System for Mobile-Communications (GSM) and its related components in Nigeria.

However, these policy tend to yield little or minimal benefits to economic growth, especially when compared with the developed countries of the world. As at 2017, according to the International Telecommunication Union (ITU) as reported by [5], Nigeria ranked 143 on the 2017 global ranking for ICT Development Index (IDI). In spite of growing computerization and the growth of local computer manufacture assembly, 80% of small businesses do not own PC and about 95% of public educational institutions do not own or have access to modern PCs. Research institutions do not have adequate number of computers and the number available are not suited to the particular purpose [6]. Most of Nigeria's wealth and power is from the control of physical assets-land, oil, iron and steel, coal. In the 21st century, as [7] argues, this cannot continue to happen simply because the major source of value and competitive advantage in the new economy is human and intellectual capital. As Nigeria lags behind in the use of ICT, its performance in relation to the knowledge based economy will also remain low.

Less attention has been paid to the impact of ICTs and its multiplier effect (knowledge economy) on economic growth. That impact is generally assumed to be beneficial, but it has not been seen as the primary aim of the engagement of the development community with the ICT sector. Hardly any relevant research has been done on the macro impact of ICTs and knowledge economy on growth in Nigeria. The main objective of this study is to find out the impact of ICTs and knowledge economy on growth of labour value added which is a proxy for economic growth in this study. Although value added by labour does not necessarily lead to poverty reduction, reductions in poverty are much more difficult to achieve without increase in productivity. The main hypothesis of the paper is that the effect is positive and significant.

Literature Review

Economic growth theories predict that economic growth is driven on investment in Information and Communication Technology (ICT). This theory was initiated by studies of [8] and [9 & 10]. Mainly, this interest was stirred up by the extraordinary degree of continuously high economic growth rates that occurred in the United States between 1992 and 2004. After that, a series of studies followed analyzing individual countries and industrial sectors, such as recently [11], [12], [13], [14], [15], [16], [17] and [18] find persuasive evidences for ICT's significance for growth and productivity increases. Most of these

studies have been reviewed by [19]. [20], indicate that ICT use and production quality are the most important factors in US economic growth in the 1990s. In addition, they provide evidence that ICT boosts growth in Finland from 0.3% to 0.7% between the early and late 1990s.

However, later macroeconomic studies based on growth accounting, [21] found that ICT accounted for 1.5 percentage points of the 2.6 percent growth rate per annum of labor productivity in the U.S. business sector in 1996–1999. [21], was skeptical of these findings. He asserted that the productivity revival in the U.S. was primarily driven by exceptionally rapid productivity growth in the production of computer hardware, peripherals and telecommunications equipment, while productivity growth in the rest of the economy remained sluggish. But as more data became available, it became increasingly evident that the productivity effects of ICT were substantial in most industries [22]. In his study, [23] found that the fastest growing employer of labour in Nigeria today is the telecom industry. Specifically, the wireless telephone sector that provides services to individual customers using the GSM.

[24], showed that the relative contribution of ICT to labor productivity growth remained high in 2004–2012, i.e., after the productivity growth slowdown in the U.S. Exploring the cross-country link between specific ICT capital and productivity growth. [25], based on data for 192 countries, found that investment in telecommunications infrastructure contributed 0.20 percentage points to economic growth in high income countries in 1990–2007. Likewise, [26] found a significant relationship between telecommunications infrastructure and aggregate output based on 21 OECD countries in1971–1990. They found that about one third of economic growth could be attributed to telecommunications after controlling for simultaneity and country specific fixed effects

Theoretical and empiric evidences suggest that ICT affects through three occurring macroeconomic channels that imperatively require complementary efforts by industry and policy to stimulate the impact. The first channel widens directly the capital deepening by investment in ICT but surges growth only in the short-term, however, it is a prerequisite that establishes the base for the ICT usage. The second direct channel stimulates the Total Factor Productivity (henceforth TFP) growth in the ICT sector induced by accelerated technological advances. The latter two channels require appropriate high per worker capital to be triggered and the extent of impact is particularly strong in combination

with a high stock of R&D activities and associated subsidies, international openness and reduction of regulatory barriers. The third more comprehensive channel impacts the overall TFP growth by ICT use and positive spillover effects that create TFP increases throughout the entire economy. The more ICT diffuses and is applied, the more network effects lead to cross firm integration and facilitate technological progress and innovations biased by extreme knowledge accumulation. Successful exploitation of ICT utilization requires complementary efforts in building up a high stock of human capital and reorganization, such as changes in human resource management practices and organizational structures, for adopting new knowledge or technologies respectively [26].

Despite the numerous studies, the evidence of ICT contribution to economic growth in developing countries is still scarce. For instance, [27] estimate the effect of IT investment on output growth for the panel data of 36 countries over the period 1985–1993, and discussed the contrasting policy implications for IT capital investment by developed and developing economies. They reveal that return from IT capital investment is positive and significant for the developed countries in the sample but not statistically significant for the developing ones. This study attributes this gap to the low level of IT investment as well as lack of complementary assets in developing countries. They explain that complementary investments in infrastructure, human capital, and knowledge-based structures are prerequisite for IT investments to be productive which are mostly available in developed countries rather than developing ones.

Firm-lavel studies have also shown that IT use is associated with a shift toward workers with higher skill levels, a process referred to as skill-biased technical change, and these workers earn higher wages on average [28]. In addition, IT capital has been a net substitute for labor, as the use of IT allows firms to reduce headcounts or to grow output faster than employment [29]. [30], offered a competing perspective, finding not just a strong correlation between wages and computer use in German data, but equally robust correlations for workers who use pencils, pens, calculators, or telephones. They argued that these findings cast doubt on the interpretation that the wage differential reflects returns to computer use, but reflect, in fact, the nature of the work and the implied skill sets of the workers.

[31], argued that the process of skill upgrading is due to organizational changes related to computerization rather than to individual use of computers. In

particular, computer systems enable work to be shared between a worker and the system, with many standard and repetitive tasks now conducted by the system but many of the higher cognitive tasks still conducted by the worker. Correspondingly, much clerical work is conducted by automated systems today, changing the nature of clerical work to focus on more complex situations and those that require human intervention. In the case of highly educated workers, work is supported rather than automated by computers. In this view, organizational computing systems have been a substitute for low- and middle-skill white collar workers while creating more demand for high-skill workers. This process could explain the higher skill levels and wage rates associated with IT use.

The State of ICT in Nigeria

According to [32], Nigeria had a late start in the use of computers, until the mid-90s, technology in Nigerian education was mostly based on the type writer. Secondary school students were taught the use of a typewriter, however from the mid-90s till date, computer science has become a fundamental part of education. Most Nigerian university are now full of Information Communication technology facilities enabling lecturers and students to do their researches and other academic works using various IT devices. The Federal Ministry of Education embarked on the establishment of the National Virtual (Digital) Library Project in 2001. Computer installations are widely distributed in government departments and agencies, banks, commercial establishments, and industries. The private sector is also not left out in this information technological revolution. Nigeria Mobile cellular services made their first appearance on the Nigerian market in1993 with a “national” service operated by NITEL and a smaller Lagos service operated by Mobile Telecommunications Services (MTS). The two firms, with a joint subscriber base of 12 500, provided voice services over an analogue E-TACS network, as well as basic value-added services such as voicemail and paging, from three switches in Lagos, Enugu, and Abuja. However, in 1995, MTS closed its operations due to failure to pay interconnection charges to NITEL. M-Tel subsequently emerged as NITEL’s mobile service provider.

Global Systems for Mobile Communications (GSM) in the country brought an abrupt or progressive end to the problematic and highly criticized services of the Nigerian Telecommunications Limited (NITEL), that then maintained

monopoly over Nigeria's telecommunications and data services. Right from inception, it was apparent that the new wave of wireless communications held better services, opportunities and promises for Nigerians who were already soaked in complaints of poor services typical of Nigeria's public utility, corruption and lack of functional modalities to reverse the situation. The introduction of GSM in Nigeria was therefore consequent upon the deregulation of the telecomm sector, against all manner of controversies, bureaucratic red-tapism, politics, fears and expectation [33].

GSM effect was felt across the country, with chain-value variables that accelerated businesses and changed the tempo of small and medium scale enterprises, hence injecting fresh impetus into the socio-economic complexion of the country in a way that left no room for further debates or apprehension. The market was rapidly expanded beyond imaginations to herald healthy competition amongst Nigerians and foreigners alike. It has also improved the quality of living of Nigerians. Thanks to GSM, Nigerians now enjoy services like mobile TV, POS (electronic payment), affordable internet services, mobile tracking services, cheaper international calls, internet banking, and mobile banking [32].

However, the cost and acquisition of ICT gadgets and its attendant installation of software's in the country drills a hole into the pocket of the average Nigerian. ICT has been blamed for the antisocial behaviour prevalent in the society. The internet is a virtual world, an extension of reality but research as confirmed that individuals spend and prefer to exist in the virtual world. Majority of Nigerians including our students are now so dependent on technology for the collection and recollection of data and information that the brain seems to be in a state of inertia. ICT gadgets due to their far reaching capacity have been used by terrorists to create awareness and instill recognition and fear in the minds of the people. Kidnappers and ritualists have through this medium deceived several people under the guise of trying to move from been virtual friends to real friends. Youths have attached their sense of identity to their possession of the latest gadgets and are gratified when they have a good number of views and likes on the social media. Not achieving these goals have led to depression and other desperate actions such as posing nude, cybercrime, kidnapping and armed robbery. Furthermore, ICT project ill health-related problems, the country has become a dumping ground for foreign rejects, an environmental threat. Telephones emit electromagnetic waves which has been the cause of deaths by

explosion. Light from television and computer screens have been discovered to be dangerous to the eyes. Despite the discourses and cynicism, according to [1], ICT has been able to:

- Reduce transaction costs and thereby improve productivity.
- Offer immediate connectivity–voice data, visual- improving efficiency, transparency, and accuracy.
- Substitute for other, more expensive means of communicating and transacting, such as physical travel.
- Increase choice in the market place and provide access to otherwise unavailable goods and services.
- Widen the geographic scope of potential markets.
- Channel knowledge and information of all kinds.

This attributes listed above is closely linked to the extent to which different ICT technologies have diffused across our economies. This is partly because ICT is a network technology; the more it's used the more benefits it generates. The diffusion of ICT currently differs considerably between the government and private sectors due to considerable challenges. These challenges have undermined the intended success to promote ICT for economic development through education and expand effective access in ensuring that the digital divide in Nigeria is bridged. Some of these challenges that needs to be addressed are; unreliable power supply, inadequate and poor ICT infrastructures, limited connectivity, inadequate educational facilities (in fact, majority of educational institutions in Nigeria do not have power supply during school hours, no computers/labs, no networks, no Internet access, no telephone lines, and no educational radios or televisions), inadequate capacity and cost hinder access, few qualified ICT educators, inadequate teacher education programs, large classes due to limited teachers, insufficient educational resources, outdated and unrelated curriculum, bottleneck and redundant regulatory policies that hinders potential benefits [34].

Knowledge and Growth

Search for the foundations of economic growth have been on by economists over the years. Traditional production functions see knowledge and technology as external influences on production and focus on labour, capital and materials.

Analytical approaches are being developed so that knowledge can be included more directly in production functions. The productive capacity of other factors of production can be increased by investments in knowledge as well as transform them into new products and processes. Long-term economic growth can be through these process because knowledge investments are characterized by increasing (rather than decreasing) returns.

Returns diminish as more capital is added to an economy but these effect can be offset by the flow of new technology According to the neo-classical production function. Although technological progress is considered an engine of growth, there is no definition or explanation of technological processes. In new growth theory, knowledge can raise the returns on investment, which can in turn contribute to the accumulation of knowledge. It does this by stimulating more efficient methods of production organisations as well as new and improved products and services. There is thus the possibility of sustained increases in investment which can lead to continuous rises in a country's growth rate. Knowledge can also spill over from one firm or industry to another, with new ideas used repeatedly at little extra cost. Such spillovers can ease the constraints placed on growth by scarcity of capital.

Technological change raises the relative marginal productivity of capital through education and training of the labour force, investments in research and development and the creation of new managerial structures and work organization. Analytical work on long-term economic growth shows that in the 20th century the factor of production growing most rapidly has been human capital, but there are no signs that this has reduced the rate of return to investment in education and training [35]. Investments in knowledge and capabilities are characterized by increasing (rather than decreasing) returns. These findings argue for modification of neo-classical equilibrium models– which were designed to deal with the production, exchange and use of commodities – in order to analyze the production, exchange and use of knowledge [36].

Incorporating knowledge into standard economic production functions is not an easy task, as this factor defies some fundamental economic principles, such as that of scarcity. Knowledge and information tend to be abundant; what is scarce is the capacity to use them in meaningful ways. Nor is knowledge easily transformed into the object of standard economic transactions. To buy knowledge and information is difficult because by definition information about

the characteristics of what is sold is asymmetrically distributed between the seller and the buyer. Some kinds of knowledge can be easily reproduced and distributed at low cost to a broad set of users, which tends to undermine private ownership. Other kinds of knowledge cannot be transferred from one organisation to another or between individuals without establishing intricate linkages in terms of network and apprenticeship relationships or investing substantial resources in the codification and transformation into information [36].

Methodology

The framework is based on the neoclassical production function model of [22] as presented by [37], where a gross output production function relates output to labor, capital, intermediate inputs and TFP. The basic idea is to determine the relation between ICT, knowledge economy and economic growth while allowing for other key influences on both variables. These are presented accordingly.

$$Y_{i,t} = A_{i,t} f_{i,t}(K_{ICT,i,t,} K_{N,i,t,} R_{i,t,} L_{i,t,} M_{i,t}) \quad (1)$$

Where $Y_{i,t}$ is real gross output, $K_{ICT,}$ is ICT related capital and K_N is non-ICT capital, R is R&D capital, L is labor input, M is intermediate input and A is Hicks-neutral TFP, all for industry i at time t. Assuming an augmented Cobb-Douglas production function, we get the following equation:

$$Y_{i,t} = A_{i,t} K_{ICT,i,t}^{\beta ICT} K_{N,i,t}^{\beta_N} R_{i,t}^{\beta_R} L_{i,t}^{\beta_L} M_{i,t}^{\beta_M} \quad (2)$$

By taking natural logarithms of equation (2), we obtain the following expression:

$$Y_{i,t} = \beta_{i,t} \ln K_{ICT,i,t,} + \beta_N \ln K_{N,i,t,} + \beta_R \ln R_{i,t,} + \beta_L \ln L_{i,t,} + \beta_M \ln M_{i,t} + \ln A_{i,t} \quad (3)$$

Where β represents the output elasticity of each input.

Methods of Data Analysis

Specifically, the Engle-Granger two step modeling (EGM) procedure [38] involving: Cointegration analysis and error correction model will be used. Based on the Granger Representation Theorem (GRT), if two or more variables are cointegrated, there exists an Error Correction Model (ECM) which relates these variables in the short-run while maintaining the consistency of the OLS estimated long-run parameter obtained in the cointegrating regression. In this

instance, ECM indicates the periodic change in the time series variables and how it eventually returns to its long run equilibrium value. Since the ECM equation contains only stationary variables which preclude spurious regression, granger causality test can be applied. This is because cointegration analysis shows that there is causality amongst variables but it does not reveal the direction of such causality.

Scope and Sources of Data

Annual data for the period 1993–2016 was employed in the study because MTS closed its operations due to failure to pay interconnection charges to NITEL. M-Tel subsequently emerged as NITEL's mobile service provider in 1993. The choice of annual data was informed by their availability throughout the study period, in addition to the overriding advantage of using annual data which has been proven to be resistant to short-run transitive and seasonal shocks [39]. Data used in this study were obtained from [40], [41] and [42]. The database contains selected macroeconomic data series from the statistical appendix of the World Bank Outlook report, which presents the World Bank staff's analysis and projections of economic developments at the global level, in major country groups and in many individual countries. The Data description, definition and sources are given as follows:

1 Service value added per worker [40]: Is an indicator that measures the 'value-added' per worker and is an outstanding measure of the extent to which you are utilizing your workers strength. Value added reflects the contribution of labour to production. It also designates the degree of accomplishment of collaboration and labors by the various parties involved in the production process. The higher the figure the better it is. In general, rising added-value per worker is positively suggestive of the rising productivity.

2 Internet subscribers [40&41]: They are those who use the Internet from any location. As an information distribution system, the Internet and its usage provide opportunities for bringing education and information within the reach of all. It can significantly shorten time lags as well as opening up a new range of information resources. It also opens up significant, new economic opportunities as well as possibilities for more environment-friendly options for the marketplace. The Internet can allow businesses from developing nations to leapfrog into the development mainstream

and offers considerable promise in facilitating the delivery of basic services, such as health and education, which are unevenly distributed at present. It is a measure of economic development. The relationship is expected to be positive.

3 Mobile phone subscribers [40&41]: It measures the number of mobile phones in a country although it might not measure the actual number of mobile phone owner's because individual customers can own multiple sim connections. However it can be used to represent the amount of money spent to make life easier. There is unlikely to be sustainable development without a well-developed communications infrastructure. Communications is critical to support sustainable development. For instance, a well-developed communication infrastructure will reduce the need for transport with beneficial effects on the environment. Another example is the access telecommunications provides those in rural and remote areas with contact to the outside world, reducing their sense of isolation and providing them with a tool to improve economic, social and cultural awareness. The relationship is expected to be positive.

4 Gross fixed capital formation [42]: It refers to net additions of capital stock such as equipment, buildings and other intermediate goods. A nation uses capital stock in combination with labour to provide services and produce goods; an increase in this capital stock is known as capital formation. Generally, the higher the capital formation of an economy, the faster an economy can grow its aggregate income. Increasing an economy's capital stock also increases its capacity for production, which means an economy can produce more. Producing more goods and services can lead to an increase in national income levels. The relationship is expected to be positive.

5 Inflation Rate [42]: This is the percentage change in the general price level of goods and services in Nigeria from 1990- 2017. The relationship is expected to be negative.

6 Total labour Force [40]: Labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted.

7 Money supply[42]: This measures the sum of currency held by the public and transaction deposits at depository institutions (which are financial institutions that obtain the funds through deposits from the public such as commercial banks, savings and loans associations, savings banks and credit unions plus savings deposits, small denomination bank deposits. The relationship is expected to be positive.

8 Education output [42]: Education contribution to Gross Domestic Product which is usually employed to denote the size of the education sector, which is indicative of the level of research and development in the country.

9 Exchange rate [42]: It is the bilateral exchange rate between Nigeria and the USA. It is the monthly average official exchange rate of the Naira vis-à-vis the US dollar. A weak/depreciated exchange rate makes import expensive and export cheap and hence may likely impact positively on economic growth..

Model Specification

The specification of the econometric model is based on the production function (Equation 1) but the dependent variable is value added by labour rather than the total gross output because the effect of ICT occur through three macroeconomic channels which require appropriate high per worker capital to be triggered with a high stock of R&D activities, also, human capital stands out as the major factor to accelerate economic growth. We also favor value added since it has the appealing property that nominal value added sums to GDP. The specification is based on the standard augmented Cobb-Douglas production function. The specification can be written:

$$\ln LV_{i,t} = \beta_{ICT} \ln K_{ICT,i,t} + \beta_N \ln K_{N,i,} + \beta_R \ln R_{i,t} + \beta_L \ln L_{i,t} + \delta_t D_t + \varepsilon_{i,t} \quad (4)$$

Where $LV_{i,t}$ is the value added by labour in the service industry i at time t, K_{ICT} is ICT capital which will be represented by total number of internet subscribers, K_N is non-ICT capital which is represented by gross fixed capital formation, R is education output which measures the rate of research and development (knowledge economy), and L is labor force. D_t is a set of year dummy variables included in order to control for economic shocks, which will be represented by inflation, exchange rate and money supply. β is the elasticity of the subscripted

variables and ε denotes serially uncorrelated random errors. In addition to the specification in equation (4), it is also possible to divide ICT capital into hardware and software (internet subscribers and mobile phone subscribers). The specification then becomes:

$$\ln LV_{i,t} = \beta_{INTS} \ln K_{INTS,i,t} + \beta_{MBPS} \ln K_{MBPS,i,t} + \beta_N \ln K_{N,i,} + \beta_R \ln R_{i,t} + \beta_L \ln L_{i,t} + \beta_{INF} INF_{i,t} + \beta_{MS} \ln MS_{i,t} + \beta_{ER} ER_{i,t} + \varepsilon_{i,t} \quad (5)$$

Where K_{INTS} is hardware capital (internet subscribers), K_{MBPS} is software capital (mobile phone subscribers), INF is inflation, MS is money supply and ER is exchange rate.

Data Analysis Techniques

(i) Unit root Test

In order to avoid estimating spurious regression, the stochastic properties of the series were tested. This was carried out by testing for unit root which involved testing the order of integration of the individual series under consideration. Several procedures for the test of order of integration have been developed in which the most popular one is the Augmented Dickey-Fuller (ADF). The ADF test relies on rejecting a null hypothesis of unit root in favour of the alternative hypothesis of stationarity. The tests were conducted with or without a deterministic trend for each of the series in order to ascertain the level of their stationarity. The general form of the ADF is estimated by the following regression.

$$\Delta y_t = ao + a_1 y_{t-1} + \sum_{i=1}^{n} a\Delta y_1 + e_t \ldots\ldots\ldots (6)$$

$$\Delta y_t = ao + a_1 y_{t-1} + \sum_{i=1}^{n} a_1\Delta y_1 + \vartheta_t + e_t \ldots\ldots\ldots\ldots (7)$$

Where:

y_t = time series, it is a linear time trend,

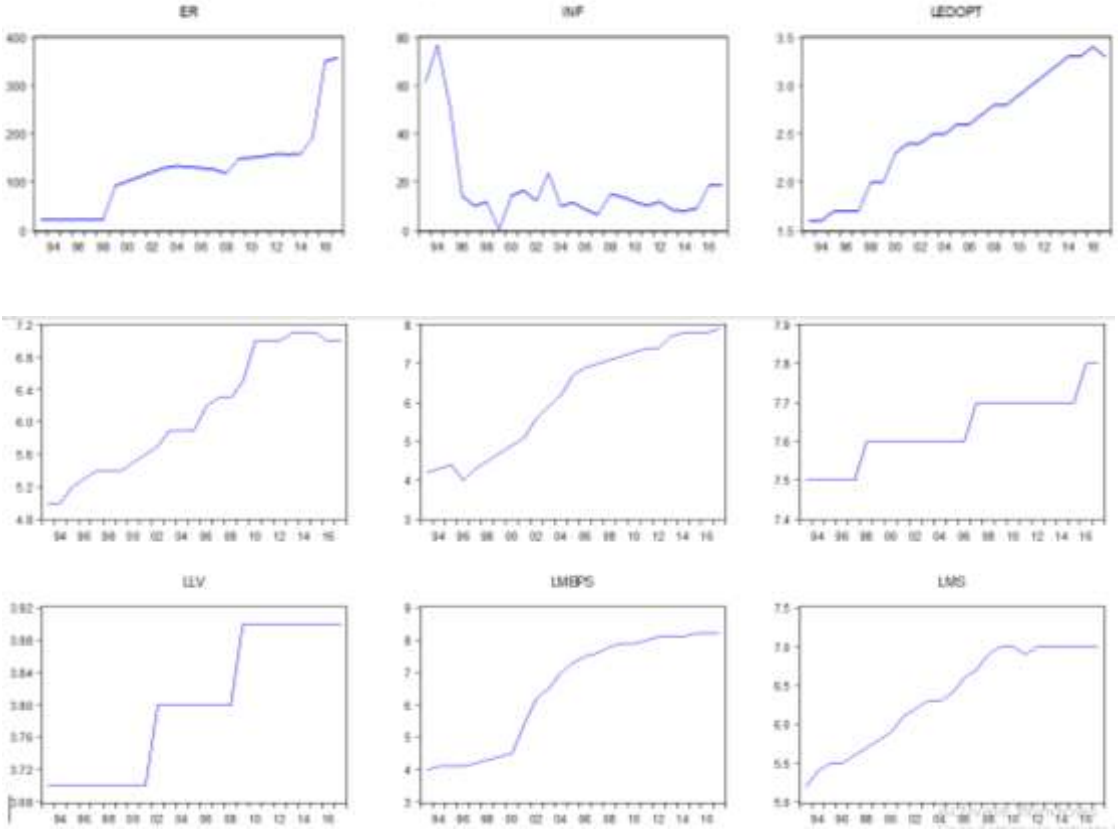
Δ = First difference operator,

ao = constant

n = optimum number of lags in dependent variable

e_t = *random error term.*

Figure 1: Variables Used for the Study



The data plots indicate that the series in their raw (undifferentiated) form is typically constantly growing or wandering about with no tendency to revert to a fixed mean. This provides an intuitive idea that the data series is non-stationary in levels and any regressions involving such variables has the potential to lead to serious errors in inferences, that is, spurious regression [43].

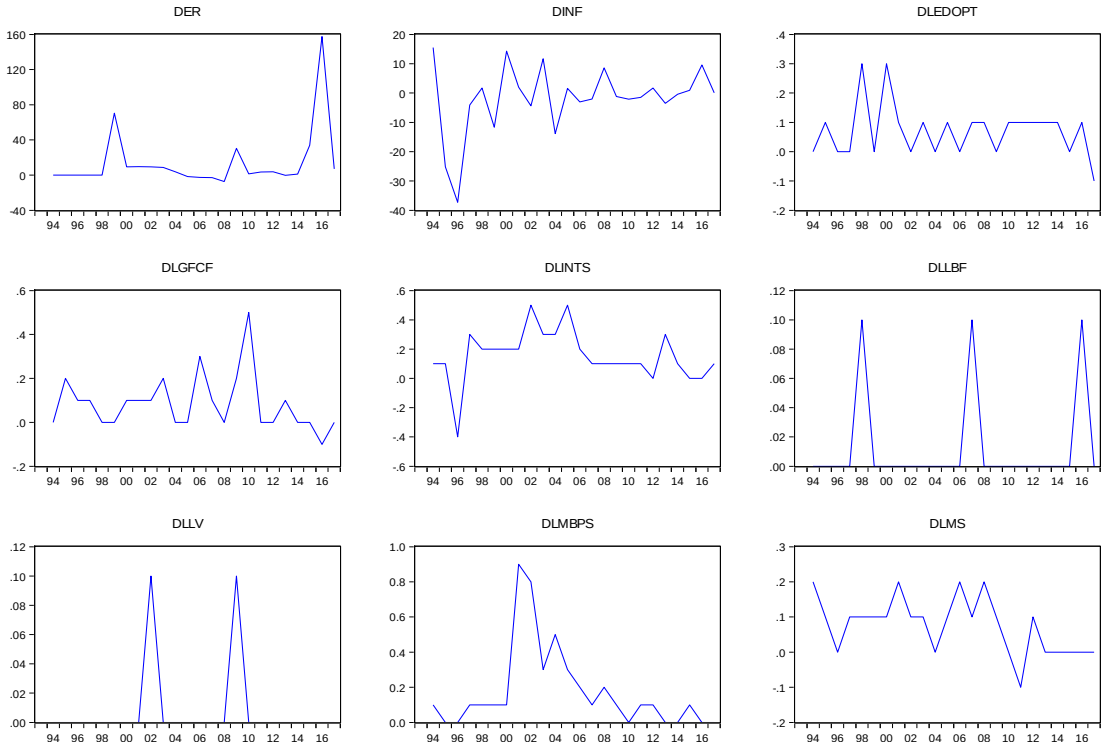
Table 1: ADF unit root test result

Var	*Test For Unit Root*	*ADF Test*	*Critical Value*			*Result*
			1%	***5%***	***10%***	
LLV	*Level*	*0.78*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-5.0*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*
LINTS	*Level*	*0.6*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-3.7*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*
LMBPS	*Level*	*0.8*	*-2.6*	*-1.9*	*-1.6*	*Not Stationary*
	1st Difference	*-1.8*	*-2.6*	*-1.9*	*-1.6*	*Stationary I(O)*
LGFCF	*Level*	*-0.9*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-4.2*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*
LEDG	*Level*	*-2.8*	*-4.4*	*-3.6*	*-3.2*	*Not Stationary*

	1st Difference	*-3.8*	*-4.4*	*-3.6*	*-3.2*	*Stationary I(O)*
LTLF	*Level*	*-2.1*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-4.4*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*
INF	*Level*	*-0.0*	*-2.6*	*-1.9*	*-1.6*	*Not Stationary*
	1st Difference	*-6.3*	*-2.6*	*-1.9*	*-1.6*	*Stationary I(O)*
ER	*Level*	*0.67*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-4.1*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*
LMS	*Level*	*-2.6*	*-3.7*	*-2.9*	*-2.6*	*Not Stationary*
	1st Difference	*-3.4*	*-3.7*	*-2.9*	*-2.6*	*Stationary I(O)*

Table 1 reveals that all variables are nonstationary at level In short, all variables are integrated of order one (i.e. they are I (1) *processes) which sets the stage for Ordinary Least Squares test. Below is the Ordinary Least Squares test result.*

Figure 2: Varibles at Stationary



Empirical Result and Analysis

Firstly, as a benchmark, the study estimated the impact of ICT and knowledge economy on economic growth using equation 5. In estimating the long run function, due care has been taken to ensure that all the variables chosen are the ones integrated to the first order. This is in line with [45], who noted that in the

Engle-Granger cointegration technique, the time series employed in the regression equation should be the ones integrated to the same order.

Table 2: Impact of ICT and Knowledge Economy on Economic Growth 1993–2017 (Ordinary Least Squares Technique)

Dependent Variable	Explanatory Variables	Coefficients	Standard Error	**t-Statistic**	(Prob)
DLLV	C	0.000990	0.0033	0.2981	0.766
	ER	-1.23E-06	1.67E	-0.073	0.941
	INF	-1.89E-05	8.21E	-0.229	0.818
	DLEDOPT	-0.070749	0.0324	-2.180	0.031
	DLINTS	0.027956	0.0180	1.5460	0.125
	DLLBF	0.050958	0.0942	0.5409	0.589
	DLMBPS	0.033866	0.0140	2.4132	0.017
	DLMS	0.006752	0.0356	0.1896	0.850
	DLGFCF	-0.000599	0.0028	-0.2109	0.833

R-Squared= 0.57: Adjusted R-squared: 0.51: DW= 2.003582: F = 0.010320

The long run equation is presented in Table 2. The economic growth model has been estimated using value added by labour in the service industry (LLV), exchange rate (ER), mobile phone subscription (LMBPS), internet subscribers (LINTS), gross fixed capital formation (LGFCF), money supply (LMS), inflation (INF), education output (LEDOPT) and total labour force (LLBF). The signs of the coefficients of (ER), mobile phone subscription (LMBPS), internet subscribers (LINTS) and money supply (LMS) variables are consistent with economic theory and in line with a priori expectations. The result have shown that ICT as represented by internet subscribers (hardware) and mobile subscribers (software) supports the work of [29] that the use of IT allows firms to reduce headcounts or to grow output faster than employment. In addition, ICT use is associated with a shift toward workers with higher skill levels, a process referred to as skill-biased technical change, and these workers earn higher wages on average.

Specification with the augmented Cobb-Douglas production function of the share of mobile phone subscription in the value added by labour in the country is clearly positive and significant. This shows that the number of subscribers

contributes a smaller proportion with a coefficient of 0.033. This means as number of subscriber's increases, value added by labour increases at 0.033 rates. It further shows that mobile phone subscription over the periods 1993-2017 has statistically improved the value added by labour in the country which agrees with [23] that the fastest growing employer of labour in Nigeria is the telecom industry (Specifically, the wireless telephone sector that provides services to individual customers using the GSM).

The implication of the education output result show that the growth of education which represents knowledge economy has significantly affected the value added by labour in the country. However, it shows that if education output decreases, value added by labour increases at 0.07 percent in the long run. The result is not in line with the belief that education is the bedrock of technology because, technological knowledge and skills can only be transferred through education. Furthermore, it shows that our education is not functional. A situation where there is no adequate educational facilities and conducive education environment. Education with a ratio of one textbook to twelve students, dilapidated school classrooms and lecture halls, education without the basic teaching, learning facilities, teachers who themselves are not better than the children they teach, is a complete mockery of sound education system and most research institutions do not have adequate number of computers and the number available are not suited to the particular [6].

The national policy on education of 2004 incorporated ICT into the educational curriculum for secondary schools and it's believed that the use of ICT in education has enhanced teaching, learning and research in Nigeria's education system, especially in terms of improvement of access and delivery of education. Online courses have also been introduced as an alternative to higher education. However, electronic technology and internet access is very expensive and not accessible to low income earners. Middle income earners have been able to access the benefits of ICT and other forms of technology in education, but how many are they? It also shows that the state of our education has not increased the level of competitiveness of the labour force in the production of goods and services.

The model's DW statistic shows the model's predictive ability to be good. With DW statistic 2.0, it implies that the model's has no first order auto correlation (that is model's error term is not serially auto correlated) and it implies positive serial correlation. However, the result of the joint test reported in table 2 reveal

that jointly, all explanatory variables included in the estimated long-run model are statistically significant at one percent level, meaning that jointly, the explanatory variables influence change in value added by labour. The adjusted R-squared result performed relatively well, it shows that 0.57% of total change in the value added by labour is accounted by exchange rate (ER), mobile phone subscription (LMBPS), internet subscribers (LINTS), gross fixed capital formation (LGFCF), money supply (LMS), inflation (INF), education output (LEDOPT) and total labour force (LLBF). This was also backed up by an Adjusted R-squared of 51% also, suggesting that about 51% variations in value added by labour in Nigeria were explained by fluctuations in the specified explanatory variables. The remaining 40.3% accounted for by the omitted variables. The standard error of 0.032; shows that a high level of confidence can be placed on the estimates. The level of significance show that inflation is contributing to the variation in the dependent variable (LLV). The level of significance of other variables (ER), (LGFCF), (LMS), and (LLBF) show that they are not contributing to the variation in the dependent variable (LLV).

Figure 3: ECM

The residual of the long run static regression in Figure 3 seem to indicate mean reversion, thereby pointing to the likelihood of cointegration. To confirm this view, a more formal test is conducted below.

Table 3: Cointegrating Residual: t-statistic

	t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic			-3.331783	0.0246
Test critical values:	1% level		-3.737853	
	5% level		-2.991878	
	10% level		-2.635542	

Table 3 show evidence of cointegration at all levels, (5% and 10%).

To check if the regression results are spurious. Hence, the need to compare the ADF statistic on residuals to the MacKinnon response surface values since the Augmented Dickey Fuller (ADF) critical values are not appropriate for testing cointegration see [44]. If the residual series is stationary, it means the regression is not spurious and that there is cointegration, implying that there is a long run equilibrium relationship among the variables. Figure 4 show that the ADF test statistic for the residual of the cointegrating equation is -3.331783. Thus, the computed 10% critical value is -2.635542, 5% critical value is -2.991878 and 1% Consequently critical value is --3.737853, the decision rule is that since the ADF test statistic of -3.331783is less than the 10% and 5%, there is evidence of cointegration at the 10% and 5% significance levels.

The Short-Run Dynamics: Error Correction Model (ECM)

After the estimation of the long run cointegration relationship, based on the Granger Representation Theorem (GRT), if two or more variables are cointegrated, there exists an Error Correction Model (ECM) which relates these variables in the short-run while maintaining the consistency of the OLS estimated long-run parameter obtained in the cointegrating regression. In this instance, ECM indicates the periodic change in the time series variables and how it eventually returns to its long run equilibrium value. The error correction model is provided in table 4.

Table 4: Error Correction Model

Dependent Variable	Explanatory Variables	Coefficients	Standard Error	t-Statistic	(Prob)
DLLV	C	0.001064	0.00334	0.3177	0.751
	ER	-1.29E-06	1.69E-0	-0.0764	0.939
	INF	-2.23E-05	8.53E-0	-0.2616	0.794

[redacted]	DLEDOPT	-0.069806	0.03274	-2.1319	0.035
[redacted]	DLINTS	0.028387	0.01824	1.5562	0.123
[redacted]	DLLBF	0.048828	0.09503	0.5137	0.608
[redacted]	DLMBPS	0.033288	0.01417	2.3486	0.021
[redacted]	DLMS	0.006179	0.03598	0.1717	0.864
[redacted]	DLGFCF	-0.000612	0.00286	-0.2137	0.831
[redacted]	ECML	-0.071136	0.09660	-0.7363	0.463

R-Squared = 0.55: Adjusted R-squared: 0.49: DW = 2.0: F = 0.003453

Eight regressors, that is, exchange rate (ER), mobile phone subscription (LMBPS), internet subscribers (LINTS), gross fixed capital formation (LGFCF), money supply (LMS), inflation (INF), education output (LEDOPT) and total labour force (LLBF) were employed to explain the short run dynamics in the behaviour of value added by labour. In line with economic theory, exchange rate (ER), mobile phone subscription (LMBPS), internet subscribers (LINTS), money supply (LMS), inflation (INF), and total labour force (LLBF) were rightly signed. Education output and gross fixed capital formation are expected to be positively related to value added by labour on a priori basis. Only the coefficients of differenced mobile phone subscription and education output variables are significant. The adjusted R^2 of 0.49 indicates that the explanatory variables explain approximately 50% of the variation in value added by labour in the short term. The F statistic indicates that the variables in the ECM are jointly significant in explaining the dependent variable. The coefficient of error correction terms (ECML) bears the required negative sign but not significant at 1%, 5% and 10%.

Conclusion

The effect of ICT and knowledge economy on the overall economic activity of developing countries have been a subject of longstanding controversy in macroeconomics and empirical scrutiny in applied policy analysis. From the analysis of data, it was observed that the effect of internet on value added by labour is positive but not pronounced. Unfortunately, the effect of education output is significant and negative which can be attributed to the country lacking the appropriate level of human capital or other complementary factors such as R&D expenditures which is inadequate and the little provided, is mostly

misappropriated or out rightly embezzled. And therefore, the gain from ICT will be low.

New technologies provide an opportunity for firms, industries and governments to "leap frog" the shortcomings of their existing technologies and close performance gaps relative to that of technological leaders. Using gross fixed capital formation (GFCF) to represent both investment in NON-ICT and government policy, the study found that GCFC has no meaningful effect on the value added by labour in the country. The effort of government in increasing production capacity has not lead to significant increase in production. This can be attributed to the level of our infrastructure more especially, energy and road network.

Since ICT and knowledge economy can play a vital role as a means for economic growth (value added by labour), it becomes necessary for the country to encourage the utilization of ICT in order to boost economic growth. From the results presented in this paper some tentative conclusions can be drawn. The country cannot get the full benefits of ICT unless they improve on the social and cultural Infrastructures and skills required for utilizing ICT's capabilities. It is essential for governments to make electricity available. Education institutions should be encouraged to embrace ICT, and underscore the role of R&D capital stock in the country. Since mobile phone subscription variable of the model has a positive effect on economic growth, it is crucial for the country to encourage firms producing phones to site their factories in the country thereby reducing cost, speed up the process of knowledge creation and facilitate ICT development. Additional analysis based on more refined econometric methods, should be encouraged to help confirm the current results.

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