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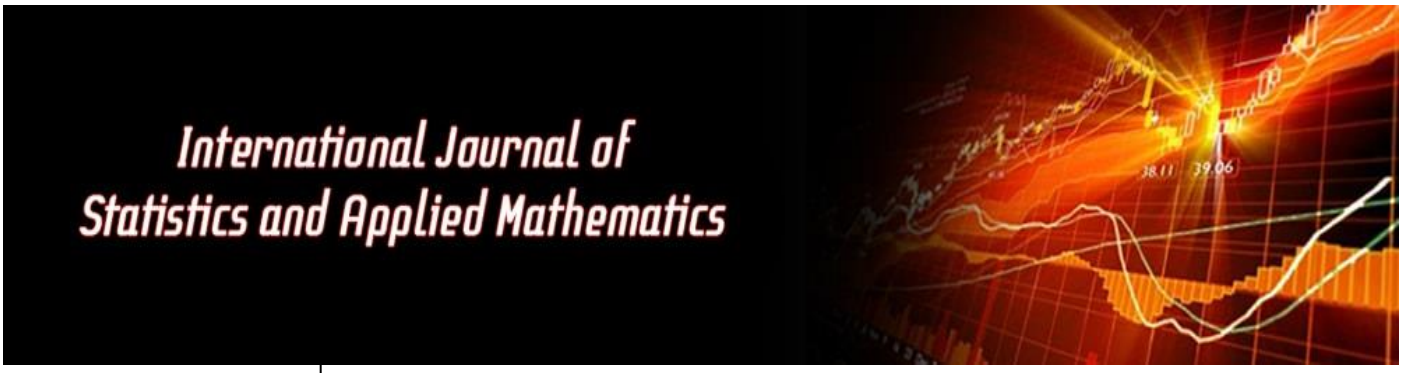

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On the contribution of information and communication technology (ICT) sector to economic growth in Nigeria: Vector error correction modelling approach

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Abstract
The Information and Communication Technology (ICT) has been the major front- runner in addressing the needs and industries of low- income communities in countries likes Nigeria. However, it was in the last fifteen years that the awareness for the importance of the ICT's role in widening the economic break through was identified. Thus, this study examined the impact of ICT sector on economic growth in Nigeria using vector error correction model for the period 1981-2020. The data for the study were collected from National Bureau of statistic. The ADF test, Johansen Co-Integration Test and Vector Error correction model was used to test the stationarity, long run relationship and short run relationship between GDP and ICT sector. The results from the data analysis indicates that all the variables were not stationary; however, become stationary after first difference. The Johansen co-integration test result showed the existence of long run relationship between the GDP and ICT sector. The study also found that LNMPSRM has positive and significant effect on GDP, also LNTIS has negative and significant effect on GDP. The ECT coefficient of 0.251 indicates that a deviation from the long run equilibrium level of the contribution of ICT sector in one year is corrected by 25.1 percent over the following year. The Granger Causality result indicates a bi-directional relationship between LNMPSRM and LNGDP; and independent relationship between LNPUB, LNTIS, LNBRD and LNGDP. In order to ensure sustainable economic growth, the study recommends that Nigeria as a country should increase her investments in ICT sector as this will enable all the sub-sectors to contribute positively toward GDP of the Country.

Keywords: Co-Integration, ICT, GDP, VECM, granger-causality

Introduction
The Federal Government of Nigeria has swiftly embarked on a drive towards the provision of more effective and efficient services in the nation by privatizing and deregulating policies which have led to the realization of National Telecommunication policy in the last quarter of 2021. Researcher have revealed that only a handful industries in the economy that have adopted the ICTs, however, there has not been a very serious study to ascertain the level of adoption of impact on the effectiveness and efficiency of the industries and consequent impact of the National Economy (David, 2021) [4].

The establishment of motion picture and sound recording system has long been assisting in the area of information and recording storage since early 1990 which has the beginning and birth of the technology devices in information processing. In Nigerian for example, about 0.8 percent of GDP is generated by the industries of motion pictures, sound recording, and music production and about 1.27 Trillion Naira of the Nation's GDP was realized by this sector in 2020. Nigeria as a country, has an enormous film industry Hollywood, which produces the highest number of movie titles in English- speaking African countries.

The Information and Communication Technology has been the major front- runner in addressing the needs and industries of low- income communities in countries likes Nigeria. However, it was in the last fifteen years that the awareness for the importance of the ICT's role in widening the economic break through was identified (Kramer, 2007) [8]. Most advance societies invested highly intensively on ICTs to breath sustainable long-term growth via production of ICT systems (Alani, 2012) [1]. For many years now ICT has been an active sector for investment because of its declining cost of services and equipment especially with the

breakthrough in cloud computing and the investment into ICT such as computers, their peripherals, software and telecommunication gadgets (Hodrab *et al*, 2016) [6].

An extensive survey that has been conducted by the International Telecommunication United states revealed that Nigeria is one of the countries with high population density and the sector of wires and wireless communication discovered to be the main sector that creates job opportunities especially in mobile phone sector (ITU, 2016) [7]. The Nigerian communication commission (NCC) revealed that the telecommunication industry contribution to GDP was 7.7% as at 2012 as against 10.43% in the mid 2018 (NCC, 2018) [9]. This revealed the great deal contribution of the telecommunication industry to the country's GDP.

On empirical evidence, Oladimeji and Folayan (2017) [10] carried out a study to identify the achievement that ICT sector provided and it impact on the Nigeria economy. The findings of the study revealed that ICT provides economic opportunities to the both urban and rural populations. The study also established that ICT increases productivity and makes the market work more efficiency. Ukwuoma (2019) [11] investigated the effect of ICT on Economic growth in Nigeria and found that increase in inflation, population and GDP per-capita have negative effect on number of internet users thereby affecting the economic growth of the Country. Waqar (2015) [13] conducted a study which aimed at understanding the impact of ICT on Country's economic output using 41 European Countries from 1996-2010 and found that ICT have strong positive correlation and causal relationship with GDP. Similarly, Billan, Mishchuk, Samoliuk and Grshnova (2019) [3] evaluate the impact of ICT on economic growth at the different hierarchical levels in Ukraine. The study established that CT development can enforce new impulse of economic progress. Albiman (2016) [2] reviewed the long run effect of ICT on economic growth in Sub-Saharan African region (1990-214) before the MDGs (1990-1999) and during MDGs (2000-2014). The study examined the non-linear effect of ICT in the economic growth and their threshold values. It was found that mobile phone and internet were found to have triggered economic growth.

From the literature reviewed, the researchers observed that there are scanty studies that investigated the contribution of ICT sector to economic growth, especially in assessing the contribution of the sub sectors of ICT such as the broadcasting; motion, pictures and sound recording; publishing; telecommunication and information services. Thus, this paper therefore seeks to examine the contributions of output from these sub-sectors of ICT to economic growth of Nigeria using.

Material and Methods

Materials

Documentary data was used in this study. The data were collected from National Bureau of Statistics (NBS) for the period of forty years (1981 to 2020).

Methods

Johansen Co-integration test and Vector Error Correction Model were employed in analyzing the data of the study.

Johansen Co-integration test

The Johansen Co-integration test was used to test for the existence of long run equilibrium between the dependent variable (GDP) and independent variables (ICT sub-sector). This was necessary due to the non-stationary nature of the variables employed in the study. The maximum Eigen values statistic test the null hypothesis of r co-integrating relations against the alternative of r +1 co-integrating relationship for r = 0, 1, 2, …, n-1. This test statistic is computed as:

$$\lambda_{max}(r, r+1) = -Tln(1 - \hat{\lambda}_{r+1}) \quad (1)$$

Where $\hat{\lambda}$ is the computed maximum Eigen values and T stands for the sample size.

At the other hand, the Trace statistic examine the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations. Here, n is the number of variable in the system for r = 0, 1, 2, …, n-1. It is computed according to the following formula:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (2)$$

Vector Error Correction Model

The vector error correction model (VECM) was employed to examine the short run relationship between the variables under study. This approach is capable of taking into account the short-term adjustments of the variables as well as the speed of adjustment of the coefficient. Therefore, the VECM measures the speed at which gross domestic product will revert to its equilibrium following a short term shock to each of them.

In order to use the VECM, the below condition must hold:

i. The variables must be stationary at first difference
ii. The co-integration between the variables must exist.

According to Pfaff (2008), the following VECM specifications usually exist:

$$\Delta y_t = \alpha \beta^T y_{t-p} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1} y_{t-p+1} + \varepsilon_t \quad (3)$$

With

$$\Gamma_i = -(I - A_1 - \cdots - A_i) \quad (4)$$

and

$$\Pi = \propto \beta^T = -(I - A_1 - \cdots - A_P) \quad (5)$$

Where Γ_i matrices contain the cumulative long run impacts, thus, this VECM specification is signified by long run form. $\Pi = \propto \beta^T$ is of reduced rank. The dimension of $\propto and\ \beta$ is $k \times r$ is the co-integration rank, that is, the number of co-integrating equation that exist between the variables. Also, $\propto$ is the loading matrix and the coefficients of the long-run relationships are contained in β

Granger Causality Test

M Finally, Granger Causality was employed to determine the direction of the causality among ICT variables and gross domestic product which is given as follows:

$$LNGDP_t = \beta_0 + \sum \lambda_{1t} LNBRD_{t-1} + \sum \lambda_{2t} LNMPSRM_{t-1} + \sum \lambda_{3t} LNPUB_{t-1} + \sum \lambda_{4t} LNTIS_{t-1} + V_t \quad (6)$$

Where

GDP: Gross Domestic Product, LNBRD, LNMPSRM, LNPUB and LNTIS are the sub-sectors of ICT, $V_t = error\ term,$ t = current period, t-1 = lag period.

Unit Root Test

The study employed Augmented Dickey Fuller (ADF) to test the stationarity of data. Here, the parametric correction for higher-order correlation are constructed by assuming that the time series data follow an autoregressive of order p process and adding p lagged difference terms of the dependent variables y to the right hand side of the test regression as follows:

$$\Delta y_t = a y_{t-1} + x_t' \delta + B_1 \Delta y_{t-1} + B_2 \Delta y_{t-2} + \cdots + B_p \Delta y_{t-p} + v_t \quad (7)$$

Where x_t are optional exogenous regression which may consist of constant or constant and trend.
The null hypothesis to be tested is given by:

$H_0: \theta = 0$, implying that the data needs to be difference to make it stationary. Against the alternative hypothesis:
$H_1: \theta < 0$, Implying that the data is trend stationary and needs to be analyzed by means of using time trend in the regression model instead of differencing the data.

The test statistics is conventional t-ratio for a:

$$t_a = \frac{\widetilde{a}}{se(\widetilde{a})} \quad (8)$$

Where $\widetilde{a}$ is the estimate of a, and $se(\widetilde{a})$ is the coefficient standard error

Results and Discussion

Table 1: Descriptive Statistics

	LNGDP	LNBRD	LNMPSRM	LNPUB	LNTIS
Mean	8.703573	3.678560	3.760894	2.452880	1.315383
Median	8.929050	3.424563	4.475675	2.568085	1.241264
Maximum	11.93377	5.674045	7.698728	7.170758	3.614156
Minimum	4.926746	1.658228	-0.544727	-2.813411	-1.021651
Std. Dev.	2.408241	1.130771	3.010009	3.894910	1.352602
Skewness	-0.252388	0.340765	-0.222062	-0.093767	0.195179
Kurtosis	1.625190	2.077129	1.479703	1.296882	1.977288
Jarque-Bera	3.574836	2.193624	4.180913	4.892968	1.997199
Probability	0.167392	0.333934	0.123631	0.086598	0.368395
Sum	348.1429	147.1424	150.4357	98.11518	52.61532
Sum Sq. Dev.	226.1854	49.86708	353.3461	591.6426	71.35175
Observations	40	40	40	40	40

Source: E-EVIEWS 9 output

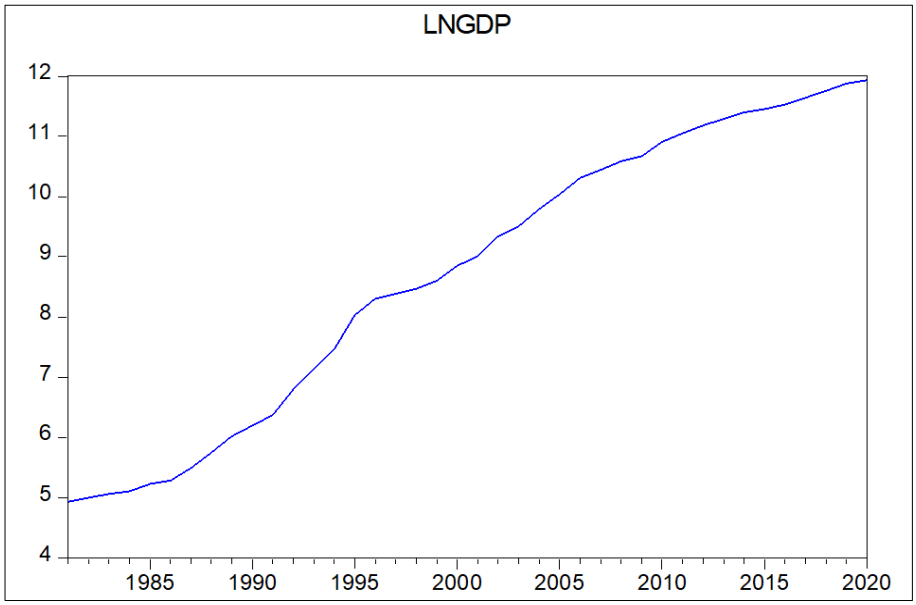

Fig 1: Plots of LNGDP

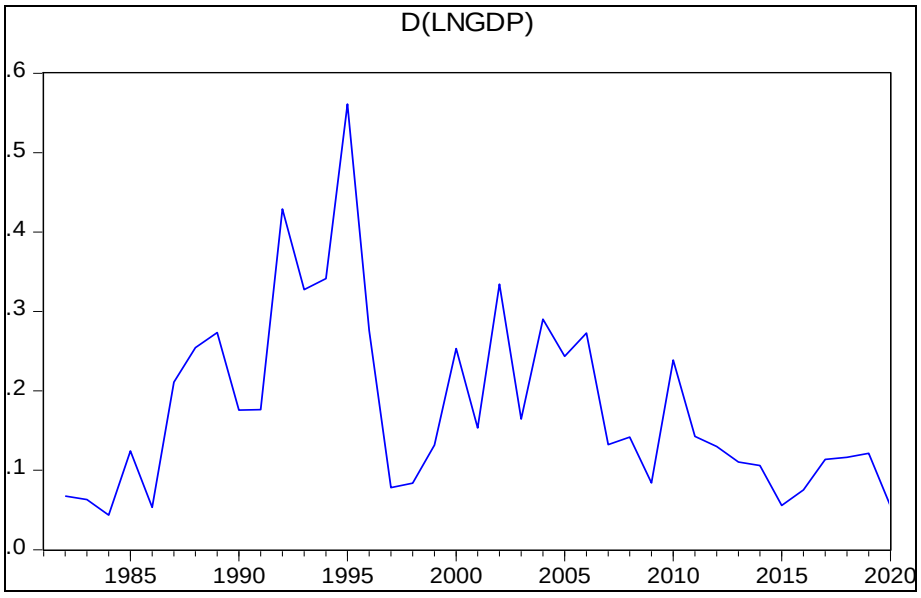

Fig 2: Plots of LNGDP at first Difference

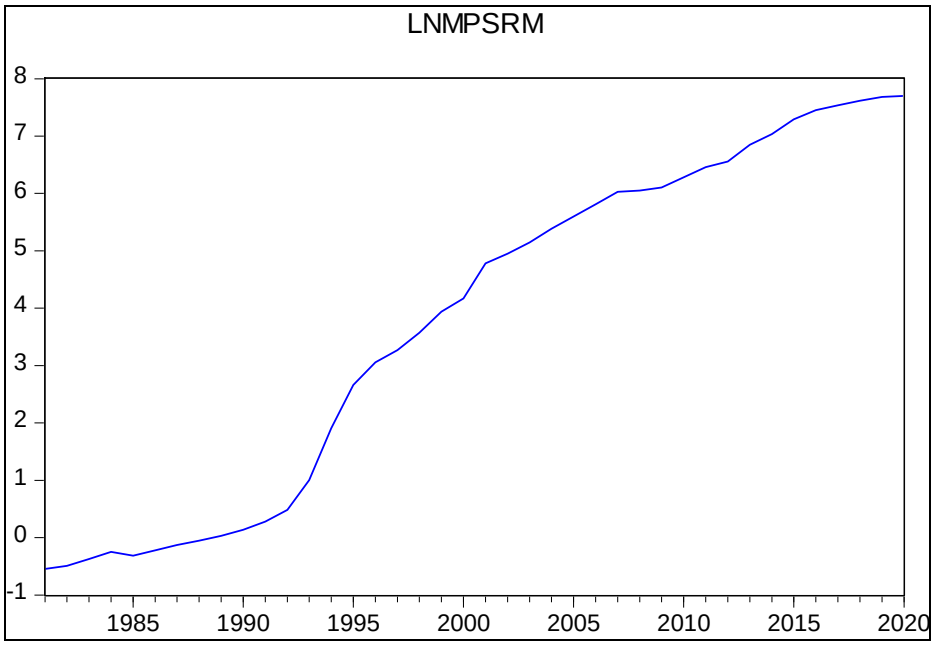

Fig 3: Plot of LNMPSRM

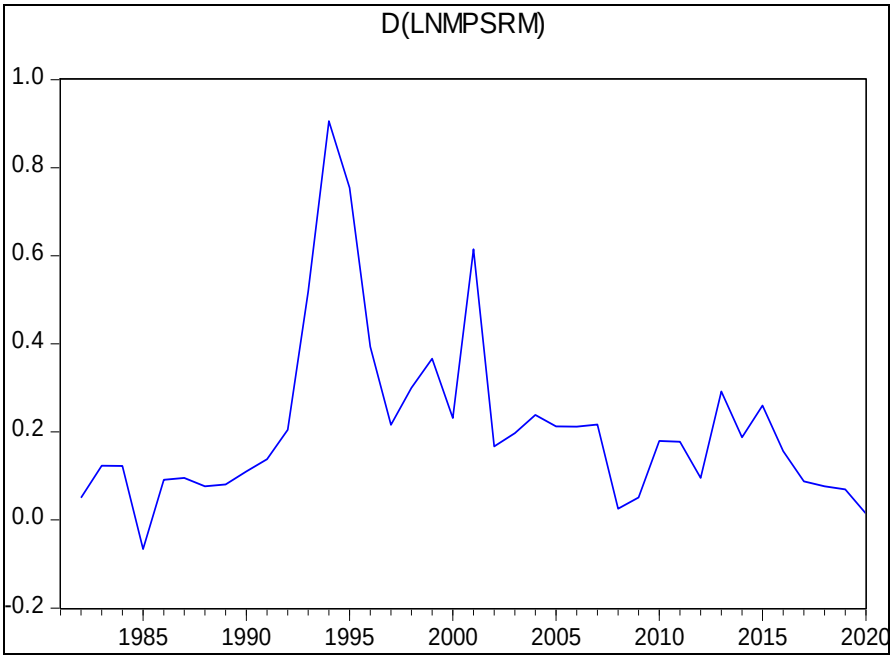

Fig 4: Plot of LNMPSRM after first difference

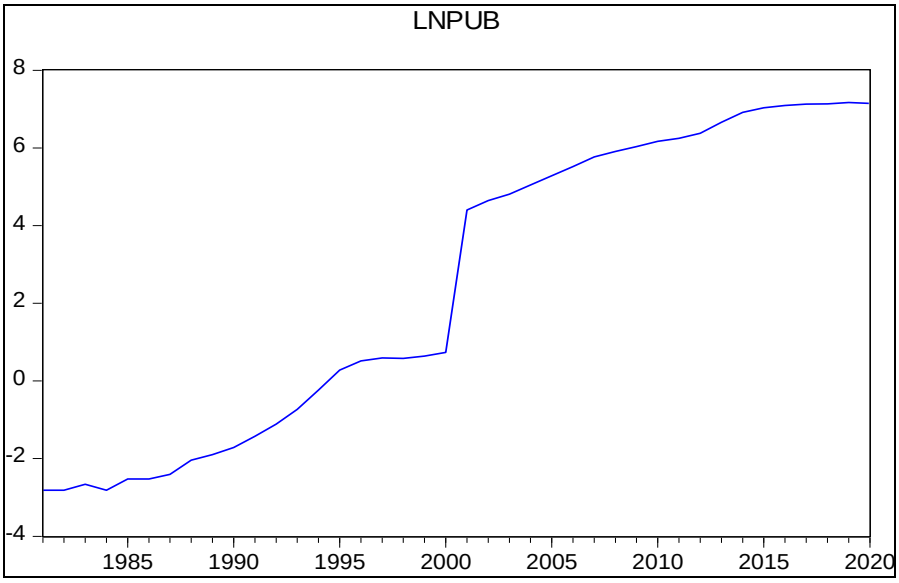

Fig 5: Plot of LNPUB

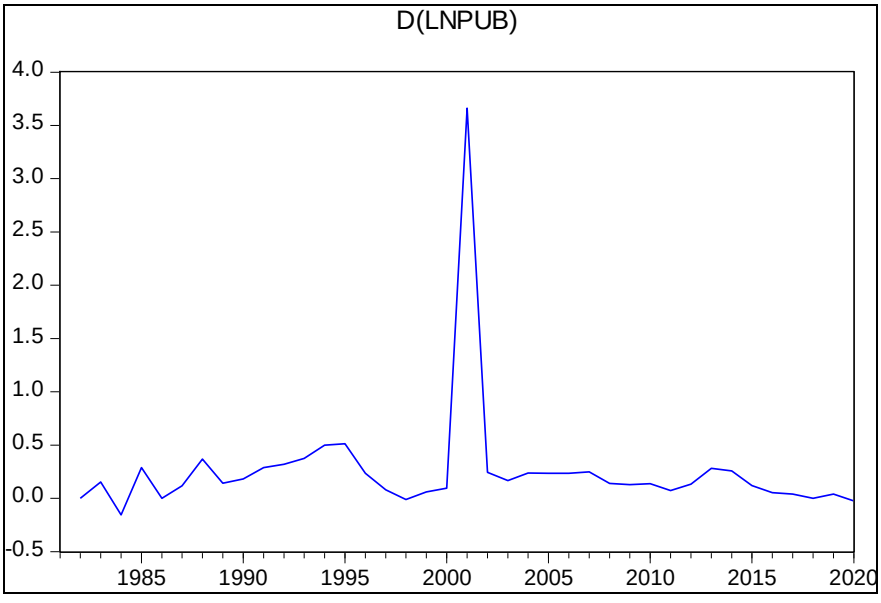

Fig 6: Plot of LNPUB at first difference

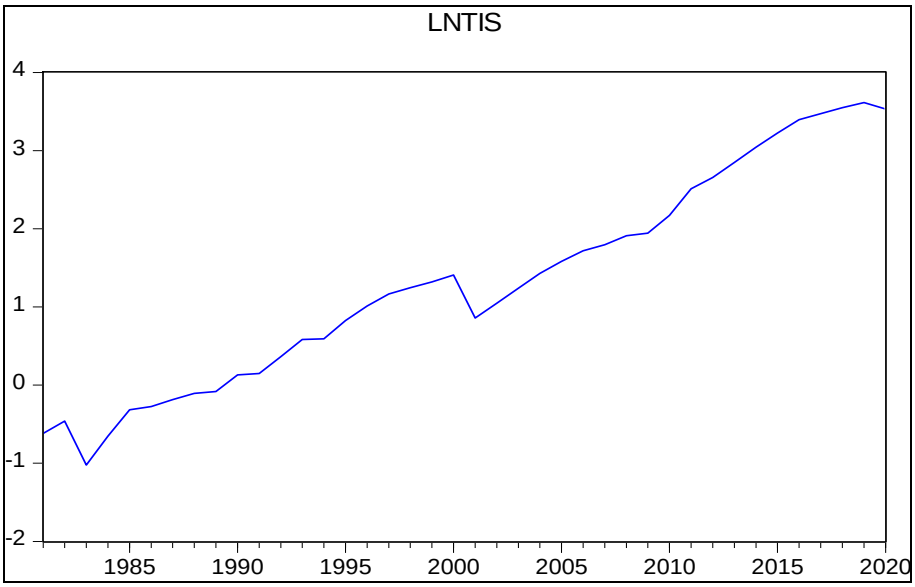

Fig 7: Plot of LNTIS

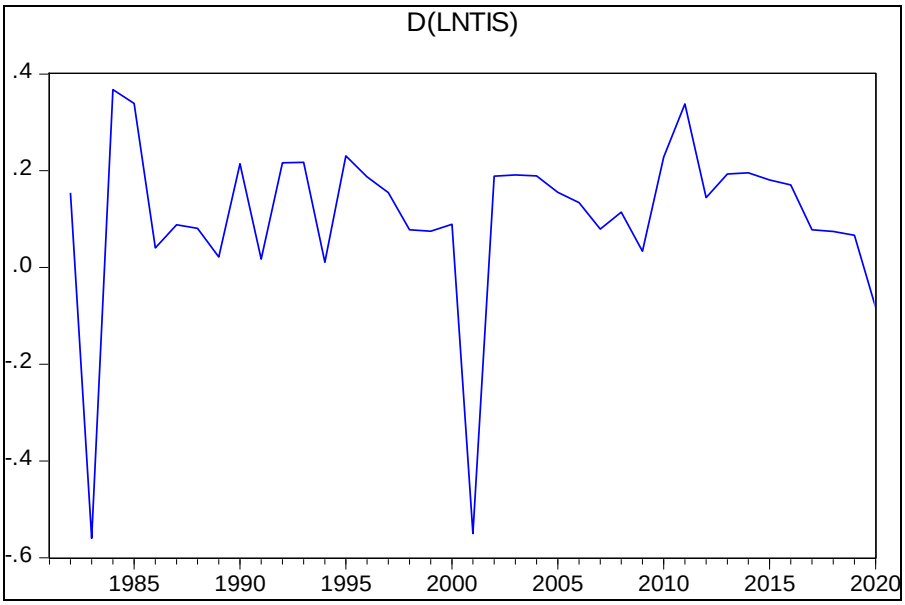

Fig 8: Plot of LNTIS at First Difference

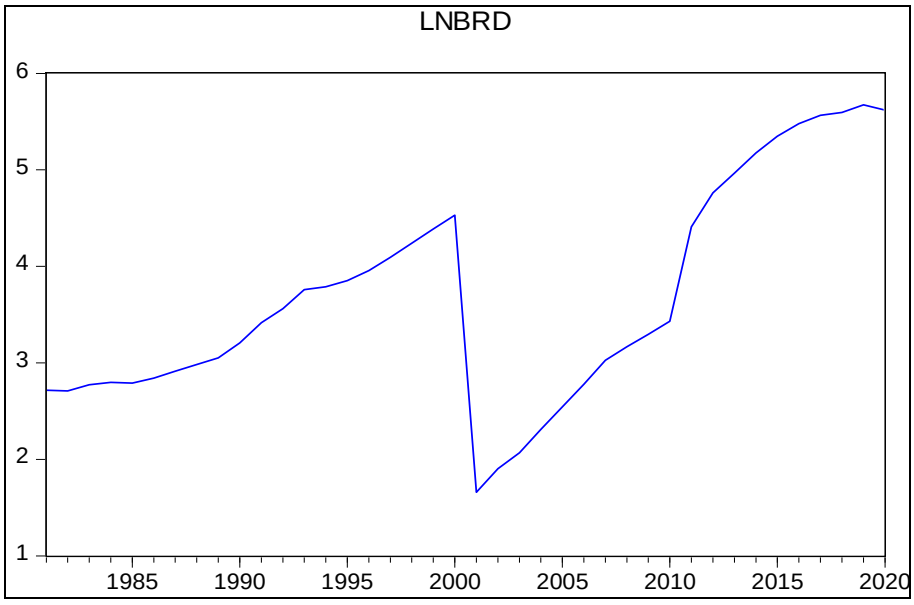

Fig 9: Plot of LNBRD

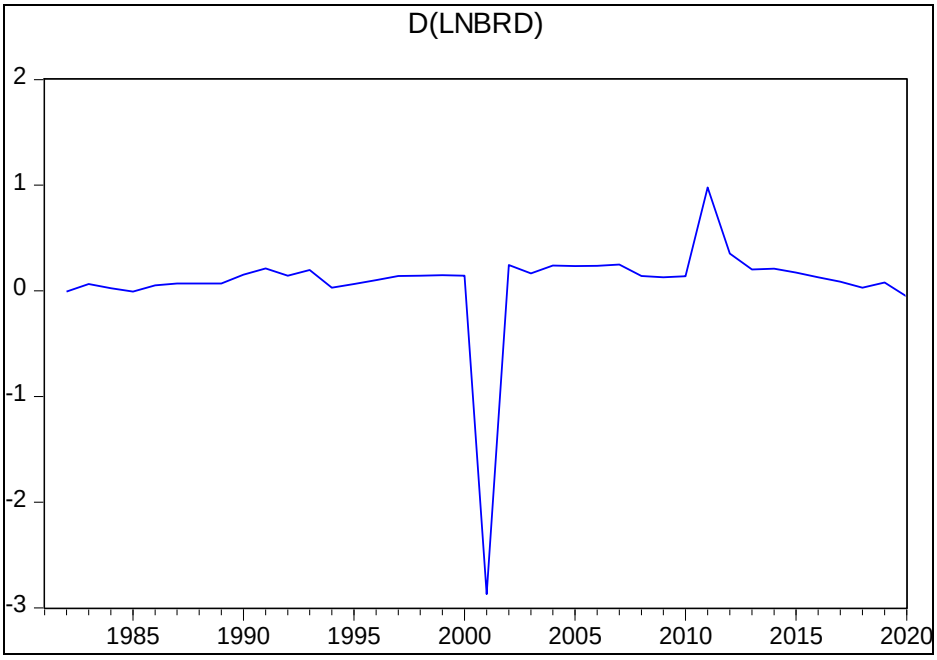

Fig 10: Plot of LNBRD at First Difference

From table 1, LNGDP stand for log of Gross Domestic Product; LNBRD stand for Log of Broadcasting; LNMPSRM stand for log of motion, pictures and sound recording; LNPUB stand for log of publishing and LNTIS stand for log of telecommunication and information service. It can be observed that the mean values for log of GDP, LNBRD, LNMPSRM, LNPUB and LNTIS were 8.703573, 3.678560, 3.760894, 2.452880 and 1.315383 respectively. The line graph indicates that all the variables were not stationary however, after taking the first difference, it became stationary. The analytical results using Augmented Dickey fuller were presented in Table 2.

Table 2: ADF stationery Test at level and first difference

Variables	Level				First Difference			
	ADF Statistic	5% Critical Value	10% Critical Value	P-value	ADF Statistic	5% Critical Value	10% Critical Value	P-value
LNGDP	-1.3228	-2.9390	-2.6079	0.6093	-3.3197	-2.9412	-2.6091	0.0209
LNBRD	-1.0079	-2.9390	-2.6079	0.7410	-6.0882	-2.9412	-2.6092	0.000O
LNPUB	-0.6670	-2.9390	-2.6079	0.8433	-5.9884	-2.9412	-2.6091	0.0000
LNMPSRM	-1.0857	-2.9411	-2.6033	0.7115	-2.7384	-2.9412	-2.6091	0.0470
LNTIS	-0.0147	-2.9390	-2.6080	0.9514	-6.6821	-2.9412	-2.6091	0.0000

Source*:* E-EVIEWS 9 output

The Table 2 presents the results of ADF stationarity test of the time series data. The result indicates that all the variables of original log transformed data were not stationary. This is evidence by the critical values which were found to be less than the ADF statistics and also p-values greater than 0.05. However, after first difference, all the variables become stationary at 5% and 10% critical values (Critical values greater than the ADF statistic) also, p-value less than 0.05. Since, all the variables were stationary after first difference, the researcher when ahead to test for the existence of long run relationship using Johansen Co-integration test.

Table 3: Co-integration Test

Series: LNGDP LNBRD LNPUB LNMPSRM LNTIS				
Lags interval (in first differences): 1 to 1				
Unrestricted Co-integration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.711006	86.46883	69.81889	0.0013
At most 1	0.479786	39.29760	47.85613	0.2486
At most 2	0.201895	14.46402	29.79707	0.8136
At most 3	0.114198	5.894441	15.49471	0.7080
At most 4	0.033288	1.286483	3.841466	0.2567
Unrestricted Co-integration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.711006	47.17123	33.87687	0.0008
At most 1	0.479786	24.83358	27.58434	0.1081
At most 2	0.201895	8.569576	21.13162	0.8655
At most 3	0.114198	4.607959	14.26460	0.7903
At most 4	0.033288	1.286483	3.841466	0.2567

Source*:* E-EVIEWS 9 output

The result for co-integration rank test were presented in table 3. Both Trace and Max-eigen value test indicates 4 co-integration equations at 0.05 level of significance. This implies that there is a long run relationship between LNGDP and log of information and communication variables (LNMPSRM, LNTIS, LNPUB, LNBRD).

Table 4: Result of Vector Error Correction Model

Variable	Coefficient	t-statistics	P-value
ECT(-1)	-0.2506	-2.1672	0.0332**
LNGDP(-1)	-0.1289	-0.4087	0.6839
LNGDP(-2)	-0.5281	-1.8434	0.0690*
LNGDP(-3)	-0.1985	-0.9462	0.3469
LNBRD(-1)	0.2512	1.5629	0.1220
LNBRD (-2)	0.0494	0.3125	0.7555
LNBRD (-3)	-0.1014	-1.1891	0.2379
LNMPSRM(-1)	0.7054	4.0672	0.0001***
LNMPSRM (-2)	0.07155	0.3329	0.7401
LNMPSRM (-3)	0.1927	0.9140	0.3635
LNPUB (-1)	6.00E-05	0.000627	0.9995
LNPUB (-2)	-0.03677	-0.3342	0.7391
LNPUB (-3)	-0.1063	-1.4391	0.1540
LNTIS(-1)	-0.7342	-3.0050	0.0035**
LNTIS (-2)	-0.2333	-1.1425	0.2566
LNTIS (-3)	-0.1552	0.1541	0.3168
Constant	0.2947	4.1489	0.0710*
R-square	0.8519		
Adjusted R-square	0.6760		
F-statistics	4.8441		

Source*:* E-EVIEWS 9 output
Note: *p<0.10, ** p<0.05, ***p<0.01 and ^{ns} not significant

Table 4 presents the results of VECM used in establishing the dynamic short-run effect of the information and communication Technology on gross domestic product. The first and second period lag of broadcasting (BRD) has positive and significant effect on gross domestic product with coefficient 0.2512 and 0.0494 with p-values 0.1220 and 0.7555 > 0.05. However, the third period lag of BRD has negative and insignificant effect on GDP. The results of the analysis also indicate that the first period lag of motion, picture and sound recording (MPSRM) has positive and significant effect on GDP with a coefficient of 0.7054. This implies that increase in MPSRM in the previous year tend to increase GDP by 0.7054. However, the second and third period lags of MPSRM has positive and insignificant effect on GDP. In addition to the above, the first period lag of log publicity (PUB) has positive and insignificant effect on GDP with coefficient 6.00E-05 and the second and third period lag of Log PUB has negative and insignificance effect on GDP. This implies that increase in the log publicity in the two previous years tend to decrease log of GDP. Furthermore, the first period lag of telecommunication and information service (TIS) has negative and significance effect on GDP with coefficient -0.7342 implying that increase in TIS in the previous section tend to decrease GDP by 0.7342. However, the second and third period lag of TIS has negative and insignificant effect on GDP.

The Error Correction Term (ECT) has a negative and significant value (ECT (-1) = -0.2506, p-value = 0.0332 < 0.05). This indicates that the ECT follows the theoretical expectation. The significance of the Error Correction Mechanism affirms the existence of long-run relationship between the variables under study. This coefficient indicates that a deviation from the long run equilibrium level of information and communication technology in one year is corrected by 25.1% over the following year.

The Adjusted R-squared of Error Correction Model is 0.8519. This implies that information and communication technology explained 85.2% of the variations in gross domestic product. The overall significant of the model was tested using the F-statistic. The F-statistic which gives a value of 4.8441 indicates that the model is significant implying that at least one of the independent variables have significant effect on gross domestic product in Nigeria.

Table 5: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
LNBRD does not Granger Cause LNGDP	37	1.26952	0.3026
LNGDP does not Granger Cause LNBRD		0.66490	0.5802
LNMPSRM does not Granger Cause LNGDP	37	7.75684	0.0006
LNGDP does not Granger Cause LNMPSRM		3.46822	0.0283
LNTIS does not Granger Cause LNGDP	37	0.79231	0.5078
LNGDP does not Granger Cause LNTIS		0.72163	0.5470
LNPUB does not Granger Cause LNGDP	37	1.30727	0.2903
LNGDP does not Granger Cause LNPUB		2.48473	0.0798
LNMPSRM does not Granger Cause LNBRD	37	0.89352	0.4558
LNBRD does not Granger Cause LNMPSRM		1.91321	0.1487
LNTIS does not Granger Cause LNBRD	37	0.80546	0.5008
LNBRD does not Granger Cause LNTIS		0.82082	0.4927
LNPUB does not Granger Cause LNBRD	37	0.88955	0.4578
LNBRD does not Granger Cause LNPUB		0.24710	0.8627
LNTIS does not Granger Cause LNMPSRM	37	1.57240	0.2166

LNMPSRM does not Granger Cause LNTIS		0.80682	0.5000
LNPUB does not Granger Cause LNMPSRM	37	1.52599	0.2280
LNMPSRM does not Granger Cause LNPUB		2.27307	0.1003
LNPUB does not Granger Cause LNTIS	37	1.84405	0.1605
LNTIS does not Granger Cause LNPUB		0.44715	0.7211

Source*:* E-EVIEWS 9 output

Table 5 presents the result for Granger causality test. It was revealed that LNMPSRM and LNGDP have a bi-directional relationship. However, there was independent relationship between LNPUB, LNTIS, LNBRD and LNGDP. This implies absent of causality between these variables.

Conclusion and Recommendations

The main purpose of this study is to examine the long and short run relationship between gross domestic product and information and communication sectors for the period 1981 – 2020. Johansen co-integration test, vector error correction model and Granger Causality test were employed to analyzed the data. The stationarity test for the variables under study was conducted through the application of ADF test, and the results showed that all the variables were not stationary at level; however, become stationary after first difference. Furthermore, the result of the Johansen co-integration test revealed that significant long run relationship exists between GDP and ICT sectors of the economy. Similarly, the result of the VECM revealed that LNMPSRM at first lag has positive and significant effect on GDP, also LNTIS at first lag has negative and significant effect on GDP. The Granger Causality result indicates a bi-directional relationship between LNMPSRM and LNGDP; and independent relationship between LNPUB, LNTIS, LNBRD and LNGDP. The ECT coefficient indicates that a deviation from the long run equilibrium level of the contribution of ICT sector in one year is corrected by 25.1 percent over the following year. It was concluded that information and communication technology sector contribute positively to gross domestic product in Nigeria. In order to ensure sustainable economic growth, the study recommends that Nigeria as a country should increase her investments in ICT sector as this will enable all the sub-sectors to contribute positively toward GDP of the Country.

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