

Information and Communication Technology Variables and Economic Growth in Nigeria

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ABSTRACT

The need to leverage technology to enhance economic activities prompted this study to investigate the impacts of information and communication technology (ICT) variables on economic growth in Nigeria over a twenty-nine-year period spanning 1996-2024 with the objectives to ascertain the growth impacts of mobile cellular subscription, internet penetration, and ICT investment. Through the autoregressive distributed lag and the kernel regularised least squares methods, the study found that growth of mobile phone subscriptions significantly increases per capita GDP growth by 0.73 percentage points, a percentage increase in internet penetration (individuals using the internet as percentage of the population) results in a 0.2 per cent increase in the growth of GDP per capita, and a percentage growth of ICT investment (public private partnerships investment in ICT) contributes the most (1.4%) to economic growth within the period reviewed. The study concludes that strengthening the digital economy is not just complementary but essential for sustainable economic progress in a developing country like Nigeria. Hence, the Nigerian government should encourage wider and more affordable mobile access by reducing tariffs and supporting telecom operators to expand coverage into rural and underserved areas. This ensures that mobile subscriptions translate into real economic activity rather than just numbers. Also, the Nigerian government and private sector should invest in broadband infrastructure and community-based internet initiatives, such as public Wi-Fi in schools, markets, and rural towns. Affordable, reliable internet will allow more citizens to participate in the digital economy and boost productivity across sectors.

Keywords: ICT, Mobile cellular subscription, Internet penetration, ICT investment, Economic growth

1. Introduction

Economic theory recognises technology as a driver for growth (Solow, 1956). Technological advancement, particularly in the 21st Century, has therefore transformed the way goods and services are produced as well as the nature of the products in many countries, even in developing countries who are considered laggards as far as technological development is concerned. In the case of Nigeria, the quest for a diversified, innovation-led growth has put information and communication technologies (ICT) at the centre of policy and research agendas for the purpose of leveraging technology for economic growth; hence the motivation of this study to analyse the impact of ICT variables on economic growth in Nigeria.

Nigeria began to use the internet in the early 1990s when email services became available. Specifically, Nigeria connected to the international web services in 1996 (Adomi, 2005) and also

keyed into the global system for mobile communication in 2001 (Ahmed & Musa, 2019). Fast forward to 2025 and it is apparent that ICT has become an integral part of the Nigerian economy with its potential to expand the scope of economic activities in the country (Ministry of Communications and Digital Economy, 2020; Nigerian Communications Commission, NCC, 2020). ICT variables such as mobile phone subscriptions, internet penetration, and ICT investment, have transformed the manner of production and largely determine the level of production of goods and services in Nigeria.

First, mobile phone subscriptions indicate the size of the population that have active mobile phones (have used cellular connections in the past six months). Specific ways that the use of mobile phones affects the economy include increasing productivity, encouraging entrepreneurship, expanding financial inclusion, creating jobs (Egbulem et al., 2024; Edeh et al., 2019), improving market efficiency, and supporting economic growth (Ojukwu et al., 2021; Dieli et al., 2020; Anadozie et al., 2019). Take financial inclusion as an example. The use of mobile phones has resulted in more people participating in the formal economy, increasing consumption and investment. More people in Nigeria now engage in mobile banking and mobile money services, such as digital payments and transfers. It has also improved peoples' access to savings, credit, and insurance (Ojeh et al., 2025). Digital literacy has also informed investment decisions in the country (Grzybowski, Lindlacher & Mothobi, 2023), all of which increases access to goods and services.

Second, rising internet penetration – fixed and mobile – improves information access, reduces search costs, and enables digital platforms, payments, and e-government. Cross-country studies find that broadband expansion is associated with higher GDP growth, especially in developing economies where marginal returns to connectivity are large (Katz, 2012; Qiang, Rossotto, & Kimura, 2009). In Nigeria, mobile broadband has driven the bulk of connectivity gains; evidence links greater penetration to growth in fintech, e-commerce, online media, and SME productivity, conditional on affordability and digital skills (NCC, 2020; World Bank, 2019; GSMA, 2020).

The growth pathways of internet penetration are diverse: online marketplaces and social commerce reduce entry barriers and expand customer reach, increasing market access for small and medium-scale enterprises (SMEs) (World Bank, 2019; GSMA, 2020); financial inclusion is enhanced as digital payments and mobile money lower transaction costs and spur formalization (Suri & Jack, 2016; GSMA, 2020)

Thirdly, internet penetration (% of population) has trended upwards between 1996 and 2024 in Nigeria. When broken down, internet use was virtually zero in the period 1996-2000, penetration remained below 1% in the period 2000-2005, limited to elites and institutions. Rapid growth with general system for mobile (GSM) rollout occurred in the period 2005-2010 and penetration rose to about 10%. Between 2010 and 2015, internet users surged past 30%, driven by mobile broadband expansion. The trend continued in the period 2015-2020, reaching nearly 45% penetration. In the period 2021-2024, over 50% of Nigerians now use the internet, with mobile devices accounting for approximately 79% of traffic. The data show that ICT trade shares remained modest but volatile, while internet penetration surged dramatically, reshaping Nigeria's digital economy. Internet penetration is the most transformative ICT variable, enabling fintech, e-commerce, and digital inclusion. However, empirical evidence backing this assertion is few and

far fetched (Odhiambo, 2019; Olatunji et al., 2015; Adewoye & Ayo, 2010) which makes the present study imperative.

Lastly, ICT investment also has a role to play in delivering the dividends of ICT. The objects of ICT investment include telecom networks, broadband, data centres, software, and digital services. It directly increases output in the economy and this is evident in the contribution of the ICT sector to the growth of gross domestic product (GDP) in Nigeria which stood at about 18% in 2024 (National Bureau of Statistics, 2024). Additionally, ICT investment brings about expansion of mobile networks, internet services, and data usage which in turn increases value addition across sectors of the Nigerian economy. Thus, ICT investment increases the efficiency of other sectors including agriculture, manufacturing, trade and services, and finance. This brings about increased productivity which leads to economic growth.

Data from World Bank (2024) indicates that public private partnerships investment in ICT in Nigerian averaged 18% in annual growth between 1996 and 2024. However, there has been a decline since 2015 with 22% reduction in the level of ICT investment in the country. Nevertheless, the potential for the ICT to drive economic growth in the country remains high and undiluted which motivated this study.

Over the past three decades, Nigeria experienced significant fluctuations in economic growth. For instance, GDP growth rate averaged 5.96 percent annually between 1996 and 2005, 6.1 percent between 2006 and 2015, but fell drastically to 1.63 percent between 2016 and 2025. Consequently, the Nigerian government has repeatedly made policy pronouncements aimed at economic diversification to stabilise the economy. Since information and communication technology (ICT) has emerged globally as critical enablers of productivity, innovation, and competitiveness, the goal is to leverage the technology to enhance economic growth. However, Nigeria's experience with ICT variables – particularly mobile phone subscription, internet penetration, and ICT investment – reveals a paradox of rapid digital adoption but limited economic gains.

Recognising this fact, the Nigerian government has taken several steps to improve the activities of the digital sector. These include digital inclusion drive and quality regulatory framework powered by the Ministry of Communications, Innovation and Digital Economy and National Information Technology Development Agency (NITDA). This is aimed at transforming Nigeria from a traditional economy to one that is driven by digital inclusion and innovation. These efforts appear to have paid off, as mobile cellular subscriptions increased from 14,000 to over 228 million between 1996 and 2024, and internet penetration from less than 1% of the population to about 45% in the same period. However, despite government efforts, GDP growth in Nigeria has been erratic. It averaged 3.1% annually between 1996 and 2000, 8% between 2001 and 2010, 2.7% between 2011 and 2020, and 3.3% in the years 2021-2024.

The degree to which the ICT variables determine economic growth in Nigeria therefore remains a research concern. Addressing the concern is essential for assessing Nigeria's economic progress. Without a clear understanding of how ICT variables interact with growth dynamics, policymakers are likely to overestimate the benefits of digital adoption or underinvesting in critical growth drivers within the ICT sector such as skills and infrastructure. This study braces itself to address the concerns. Hence, the objectives of the study are to determine the impact of mobile phone

subscription on economic growth in Nigeria, to ascertain the impact of internet penetration on the Nigerian economy, and to investigate the effect of ICT investment on economic growth in Nigeria.

2. Literature Review

2.1 Theoretical framework

The theoretical framework for this study is anchored primarily on the Solow Growth Theory and complemented by the Schumpeterian Innovation Theory and the Technology Diffusion Theory. The Solow Growth Theory, developed by Robert Solow (1956), provides the foundational explanation of how economic growth is influenced by the accumulation of capital, labour, and technological progress. Unlike earlier growth models, the Solow model identifies technological advancement as the key driver of sustained long-run economic growth beyond what can be achieved through increases in capital and labour alone. Since information and communication technology (ICT) constitutes a major form of technological progress, the theory provides a suitable basis for examining how ICT investments and digital infrastructure contribute to economic growth. In the context of this study, ICT is viewed as an exogenous technological factor that enhances productivity and increases the level of gross domestic product (GDP) in Nigeria.

While the Solow model explains the role of technology in promoting growth, the Schumpeterian Innovation Theory provides a deeper understanding of the mechanisms through which technological innovations stimulate economic transformation. Developed by Schumpeter (1934, 1942) and later formalized by Aghion and Howitt (1992), the theory argues that economic growth is driven by innovation through the process of creative destruction, whereby new technologies replace obsolete production methods, industries, and business models. ICT innovations, including broadband technologies, mobile banking, cloud computing, and digital platforms, create new markets, improve business efficiency, and enhance productivity across sectors of the economy. The theory further suggests that firms continuously invest in innovation to obtain competitive advantages, while knowledge spillovers facilitate the diffusion of technological improvements throughout the economy. Although the theory places greater emphasis on innovation creation than on adoption, it remains highly relevant in explaining how ICT-driven innovations promote long-run economic growth.

Complementing the innovation perspective, Rogers' (2003) Technology Diffusion Theory explains how technological innovations spread across individuals, firms, and societies before their economic benefits can be fully realized. The theory proposes that the adoption of new technologies follows an S-shaped pattern, beginning with innovators and early adopters before extending to the majority and eventually laggards. According to Rogers, the rate of technology adoption depends on factors such as relative advantage, compatibility, complexity, trialability, and observability.

Applied to ICT, the theory suggests that the economic impact of digital technologies depends not only on their availability but also on the speed and extent of their adoption. Variables such as broadband penetration, mobile phone usage, internet accessibility, digital literacy, and ICT infrastructure determine how effectively ICT contributes to productivity improvements, lower transaction costs, and enhanced economic performance. Although the theory has been criticized for overlooking structural barriers such as inadequate infrastructure, affordability constraints, and

institutional weaknesses, it remains valuable in explaining variations in ICT adoption and its contribution to economic growth.

2.3 Empirical review

The empirical literature provides substantial evidence of a positive relationship between ICT variables and economic growth. Several studies found that mobile cellular subscriptions, internet penetration, ICT diffusion, and ICT investment significantly enhance economic performance. Pradhan et al. (2024) reported that ICT infrastructure exerted a positive long-run causal effect on real per capita income growth in lower-income countries. Similarly, Saba and Ngepah (2022) established that ICT diffusion positively influenced economic growth across 171 countries. In Nigeria, Ojukwu et al. (2021) found that mobile cellular subscriptions significantly increased GDP growth, while Dieli et al. (2020) showed that wireless mobile technology enhanced economic growth through greater technology adoption. Myovella et al. (2020) also found that digitalisation contributed positively to real per capita income in both Sub-Saharan Africa (SSA) and OECD economies, although the magnitude differed across regions. Other studies supporting positive effects include Anadozie et al. (2019), who found that mobile phone use improved farmers' welfare; Edeh et al. (2019), who reported higher employee productivity due to mobile technology; Asongu and Roux (2017), who found ICT enhanced human development; Donou-Adonsou et al. (2016) and Albiman and Sulong (2016), both of whom concluded that mobile phones and internet usage promoted economic growth in SSA.

A second group of studies specifically examined internet penetration and ICT adoption, with most reporting favourable outcomes for growth and productivity. Benedicta and Lacheheb (2022) found that ICT adoption through computer hardware and communication equipment significantly stimulated long-run labour productivity in Nigeria. Likewise, Remeikiene et al. (2021) established that internet penetration significantly promoted economic growth in transition economies of the European Union. Sedik and Emam (2019) found that ICT usage—particularly mobile services and broadband—positively influenced economic growth, although the effects were stronger in OECD and emerging economies than in MENA and developing countries. Okoye et al. (2024) also highlighted that ICT adoption enhanced competitiveness and productivity among Nigerian firms, while Echegu (2024) concluded from a review of existing evidence that ICT development and digitisation possess substantial potential to stimulate economic growth and employment in Nigeria despite existing structural challenges.

Evidence on the impact of ICT investment is also predominantly positive. Kumari and Singh (2024) reported that most ICT infrastructure indicators, including internet, broadband, secure internet, and telephone usage, were positively associated with GDP growth across low- and high-income countries, although the magnitude varied by income group. Similarly, the International Monetary Fund (2023) found that ICT investment contributed more strongly to non-oil GDP growth in the United Arab Emirates than non-ICT investment, demonstrating its importance for economic diversification. Karlsson and Liljevern (2017) equally concluded that ICT investment significantly promoted output growth, particularly among high-, upper-middle-, and lower-middle-income countries. Although Sawng et al. (2021) primarily focused on the direction of causality, their findings indicated a positive long-run bidirectional relationship between ICT investment and income growth, suggesting that ICT investment supports sustained economic expansion.

Despite the predominance of positive findings, several studies reported negative, insignificant, or mixed effects of ICT variables on economic growth. Azu et al. (2025) found that internet penetration had no significant long-run effect on Nigeria's exports, while mobile phone subscriptions and fixed telephone lines negatively affected exports. Haftu (2019) reported that mobile phones significantly promoted economic development in SSA, but internet usage had only a negligible impact. Similarly, Donou-Adonsou (2019) found that internet usage significantly enhanced per capita income growth, whereas mobile phone subscriptions exerted only a minimal effect. Tchamyou et al. (2019) concluded that the impact of ICT on income growth depended on educational attainment, implying heterogeneous effects across countries. Albiman and Sulong (2017) likewise showed that both the short-run and long-run effects of ICT varied according to countries' income levels and the ICT indicators employed. Pradhan et al. (2021) found only long-run bidirectional causality between ICT services and economic growth, with short-run causality running from growth to ICT services. The impression from the findings of these studies is that the growth effects of ICT are conditional on factors such as the level of ICT adoption, human capital, institutional quality, income level, and the specific ICT indicators considered, thereby justifying further investigation in the Nigerian context.

Despite growing literature, gaps remain on disaggregating ICT variable. Some of the studies in Nigeria or the Sub-Saharan Africa (see Ojukwu et al., 2021; Dieli et al., 2020; Haftu, 2019) focused on ICT usage, in terms of mobile cellular subscriptions, while some (Azu et al., 2025; Benedicta & Lacheheb, 2022), dwelt on internet penetration. However, none of the studies incorporated ICT investment. A study jointly examining ICT usage, internet penetration, and ICT investment in a unified framework – while controlling for institutional quality – can clarify both direct and mediated impacts on growth, informing priorities for increased ICT usage, deeper internet penetration, and increased ICT investment. The present study serves this purpose.

3. Methodology

3.1 Research design

This research adopted the ex post facto research design. This is because the study investigated a cause-and-effect relationship using historical time series data for the period 1996-2024. The study employed regression analysis to investigate the impact of ICT variables (ICT usage, internet penetration, ICT investment) on the dependent variable (per capita GDP) and the tool of data analysis was STATA 16.

3.2 Model specification

The Solow model explains long-run economic growth through capital accumulation, labour growth, and technological progress. The Solow model is of the form of the Cobb-Douglas production function,

$$Y_t = K_t^\alpha L_t^{1-\alpha} A \quad 1$$

where:

Y_t = output (GDP)

K_t = capital stock

L_t = labour force

A = technology (exogenous in the classical model)

To study ICT's impact, we treat ICT usage (number of mobile cellular subscriptions) and internet penetration as augmentations of technology (A) and capital deepening, and ICT investment as exogenous. Hence, the researcher modified the technology term as follows:

$$A_t = f(\text{MOBP}, \text{INTPEN}, \text{ICTINV}) \quad 2$$

where:

A = Level of technology

MOBP = Number of mobile phone/cellular subscriptions

INTPEN = Internet penetration

ICTINV = ICT investment

Thus, the production function is modified as:

$$Y_t = K_t^\alpha \cdot L_t^{1-\alpha} \cdot f(\text{MOBP}, \text{INTPEN}, \text{ICTINV}) \quad 3$$

We modified the model used by Ojukwu, Nsofor, and Moedu (2021) to estimate the impact of GSM usage on economic growth in Nigeria. Their model was specified as,

$$\text{RGDP}_t = \alpha_0 + \alpha_1 \text{EXCHR}_t + \alpha_2 \text{INFLR}_t + \alpha_3 \text{MCS}_t + \alpha_4 \text{INTR}_t + \mu_t \quad 4$$

Where RGDP = real GDP, EXCHR = exchange rate, INFL = inflation rate, MCS = mobile cellular subscription, and INTR = interest rate. We modified the model by replacing EXCHR, INFL, and INTR with control variables that are more akin with the Solow growth theory, namely, gross capital formation and labour. Hence, we integrated Equation 3 into Equation 4 based on the modifications outlined. Also, we introduced regulatory quality of the government as an intervening variable to depict the level of macroeconomic stability in the country which previous studies omitted. This gives the following empirical model,

$$\text{GDP} = f(\text{MOBP}, \text{INTPEN}, \text{ICTINV}, \text{GCF}, \text{LBF}, \text{REGQ}) \quad 5$$

Where, GDP = Gross domestic product (per capita), MOBP = Number of mobile phone/cellular subscriptions, INTPEN = Internet penetration (individuals using the internet, % of population),

ICTINV = ICT investment (public private partnerships investment in ICT), GCF = Gross capital formation, LBF = Total labour force, REGQ = Regulatory quality

Taking logarithm of the nominal values on both sides, the stochastic model is expressed as follows:

$$\ln GDP_t = \beta_0 + \beta_1 \ln MOBP_t + \beta_2 \ln INTPEN_t + \beta_3 \ln ICTINV_t + \beta_4 \ln GCF_t + \beta_5 \ln LBF_t + \beta_6 \ln REGQ_t + \mu_t \quad 6$$

Where, $\ln = \log$, β_0 is the regression intercept, $\beta_1 - \beta_6$ are the regression coefficients to be estimated, μ = stochastic error term, and t = time (years). The a priori expectations are: $\beta_0 > 0$, $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$, and $\beta_6 > 0$.

Likewise, the autoregressive distributed lag (ARDL) model is specified as,

$$\ln GDP_t = \beta_0 + \beta_1 \ln GDP_{t-1} + \beta_2 \ln MOBP_t + \beta_3 \ln MOBP_{t-1} + \beta_4 \ln INTPEN_t + \beta_5 \ln INTPEN_{t-1} + \beta_6 \ln ICTINV_t + \beta_7 \ln ICTINV_{t-1} + \beta_8 \ln GCF_t + \beta_9 \ln GCF_{t-1} + \beta_{10} \ln LBF_t + \beta_{11} \ln LBF_{t-1} + \beta_{12} \ln REGQ_t + \beta_{13} \ln REGQ_{t-1} + \mu_t \quad 7$$

3.3 Data discussion

- (i) **GDP:** Is gross domestic product per capita, the dependent variable. The values are in billion Naira, so it was transformed to growth rates using the log operator ($\ln$).
- (ii) **MOBP:** Is the number of mobile cellular subscriptions at any given time in the country. The values are in million so they were log-transformed into growth rates.
- (iii) **INTPEN:** Is internet penetration. It refers to individuals using the internet in a given population at a specified time. It is expressed as percentage of total population.
- (iv) **GCF:** Is gross capital formation in billion Naira, so it was transformed to growth rates using the log operator ($\ln$).
- (v) **LBF:** Is total labour force is in million of people so it was transformed to growth rates using the log operator ($\ln$).
- (vi) **REGQ:** Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development (World Bank, 2024). The values are Nigeria's score on the aggregate indicator, recorded in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. It is a ratio number so it did not require additional transformation.

3.4 Sources of data

The researcher obtained time series data for the period 1996-2024 from World Development Indicators data compiled and published by the World Bank and from the Central Bank of Nigeria Statistical Bulletin of 2024. The data are available here: [World Development Indicators | DataBank](https://data.worldbank.org/) and cbn.gov.ng/documents/Statbulletin.html.

4. Results and Discussion

Table 1: Descriptive statistics

Statistic	GDPPC	MOBP	INTPEN(%)	ICTINV	GCF	LBF	REGQ
Mean	294767.2	92626479	15.02467	688594137.9	19569.19	78293194	-0.935045
Median	327720.3	87297800	11.50000	473100000	9183.059	75478330	-0.917148
Maximum	365972.7	2.28E+08	44.43000	2023200000	97672.51	113349564	-0.681769
Minimum	196800.5	14000.00	0.008830	16700000	1494.751	53048060	-1.453853
Std. Dev.	59968.35	82773834	14.26898	707015703.9	25512.21	17668155	0.179361
Skewness	-0.547558	0.245610	0.501286	0.670461	1.841306	0.397804	-1.125854
Kurtosis	1.732844	1.586631	1.937367	1.965979	5.332759	2.042212	4.100521
Jarque-Bera	3.389332	2.705348	2.578996	3.464618	22.96243	1.873338	7.589944
Probability	0.183661	0.258548	0.275409	0.176875	0.000010	0.391931	0.022484
Sum	8548249.	2.69E+09	435.7153	19969230000	567506.6	2270502616	-27.11629
Sum Sq. Dev.	1.01E+11	1.92E+17	5700.909	688594137.9	1.82E+10	8.74E+15	0.900774
Observations	29	29	29	29	29	29	29

Source: Researcher's computations from EViews 12 (2026)

The result in Table 1 shows that GDP per capita averaged ₦294767.2 million between 1996 and 2024. Likewise, mobile cellular subscription (MOBP) averaged 92.6 million, internet penetration (INTPEN) averaged 15% of the population, ICT investment (ICTINV) averaged ₦6.8 billion. Internet penetration, in particular, ranged from 0.08 to 44.43% of the population, which implies greater penetration in the later years towards 2024. Regarding the distribution, the skewness is expected to be zero, the kurtosis should be less than 3, and the p-value of the Jarque-Bera statistic should be greater than 0.05. Evidently, all the series are normally distributed in their nominal form except gross capital formation (GCF) and institutional quality (REGQ). However, this raises no concern since the majority are normally distributed.

4.2 Stationarity test

We used the Ng-Perron unit root test to ascertain the nature of stationarity of each time series data. This method was preferred over the Dicky-Fuller or Phillips-Perron tests because it is suitable for small samples ($n < 30$) as we have in this study ($n = 29$) (Ng & Perron, 2001).

Table 2: Ng-Perron unit root test result

Series	Form	Statistics	MZa	MZt	MSB	MPT	Decision
lnGDPPC	Level	Ng-Perron test statistics	-1.14156	-0.59590	0.52200	15.9057	Non-stationary @ 5%
		Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	
	1st Diff.	Ng-Perron test statistics	-9.45600	-2.17426	0.22993	2.59148	Stationary @ 5%
lnMOBP	Level	CV (5%)	-8.10000	-1.98000	0.23300	3.17000	Non-stationary @ 5%
		Ng-Perron test statistics	-1.69469	-0.77135	0.45516	12.1642	
	1st Diff.	Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	Stationary @ 5%
INTPEN	Level	Ng-Perron test statistics	-8.37299	-2.03512	0.21306	2.96698	
		CV (5%)	-8.10000	-1.98000	0.23300	3.17000	Stationary @ 5%
	1st Diff.	Ng-Perron test statistics	-50.9770	-4.91087	0.09634	0.81851	
lnICTINV	Level	Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	Non-stationary @ 5%
		Ng-Perron test statistics	-2.63123	-1.12177	0.42633	9.20013	
	1st Diff.	CV (5%)	-8.10000	-1.98000	0.23300	3.17000	Stationary @ 5%
		Ng-Perron test statistics	-11.5571	-2.39076	0.20686	2.17026	
		Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	

Table 2: Ng-Perron unit root test result (continues)

Series	Form	Statistics	MZa	MZt	MSB	MPT	Decision
lnGCF	Level	Ng-Perron test statistics	1.21693	0.71069	0.58401	29.0810	Non-stationary @ 5%
		CV (5%)	-8.10000	-1.98000	0.23300	3.17000	
	1st Diff.	Ng-Perron test statistics	-13.3059	-2.57791	0.19374	1.84670	Stationary @ 5%
		Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	
lnLBF	Level	Ng-Perron test statistics	-34.5473	-4.02423	0.11648	1.08712	Stationary @ 5%
		CV (5%)	-8.10000	-1.98000	0.23300	3.17000	
REGQ	Level	Ng-Perron test statistics	-9.14415	-1.76673	0.19321	2.97370	Stationary @ 5%
		Critical values (CV) (5%)	-8.10000	-1.98000	0.23300	3.17000	

Source: Researcher's computations from EViews 12 (2026)

The result in Table 2 shows the four Ng-Perro test statistics (MZa, MZt, MSB, MPT) where the first two are negative and the last two positive. Also, there are four critical values at the 5% level, each corresponding to a particular test statistic. The null hypothesis is that of non-stationarity, and the decision rule is that all the test statistics should be smaller than their associated critical values (treat the negative values as negative) to reject the null hypothesis.

For log of GDP per capita (lnGDPPC) and lnMOBP (log of mobile cellular subscription), we fail to reject the null at the 5% at level but did so at 1st difference. However, we reject the null hypothesis at level at the 5% significance for internet penetration (INTPEN). The null hypothesis is rejected at the 5% level only at first difference for log ICT investment (lnICTINV) and log of gross capital formation (lnGCF). However, it is rejected at level for log of labour force (lnLBF) and regulatory quality (REGQ). Overall, the result indicates a mixed-order integration, hence, we applied the autoregressive distributed lag (ARDL) method to estimate the parameters of the model.

4.3 ARDL result

We estimated the short-run relationship, the cointegration form, and the long-run relationship.

(i) ARDL short-run/Error-correction mechanism result

Table 3: ARDL short-run result

Variable	Coefficient	Std. Error	t-Statistic	Prob.	Conclusion (5%)
lnGDPPC(-1)	0.864942	0.121901	7.095451	0.0000	Significant
lnMOBP	0.028648	0.008906	3.216554	0.0058	Significant
INTPEN	0.004072	0.004213	0.966516	0.3491	Not significant
lnICTINV	-0.022514	0.006559	-3.432419	0.0037	Significant
lnGCF	0.098042	0.039892	2.457697	0.0266	Significant
lnGCF(-1)	-0.110724	0.033688	-3.286733	0.0050	Significant
lnLBF	-3.272717	1.409641	-2.321667	0.0347	Significant
lnLBF(-1)	2.876045	1.494866	1.923948	0.0735	Not significant
REGQ	0.019162	0.025950	0.738434	0.4716	Not significant
REGQ(-1)	0.002838	0.029617	0.095831	0.9249	Not significant
REGQ(-2)	0.095560	0.030544	3.128548	0.0069	Significant
C	9.105107	6.094104	1.494085	0.1559	Not significant
CointEq(-1)	-0.135058	0.010192	-13.25097	0.0000	Significant
R-squared	0.997036				
Adjusted R-squared	0.994863				
F-statistic	458.7702				
Prob(F-statistic)	0.000000				

Source: Researcher's computations from EViews 12 (2026)

The result in Table 3 shows that, holding the other factors constant, a percentage growth in mobile cellular subscription (lnMOBP) significantly increases economic growth (lnGDPPC) by 0.03 percentage points on the average. Internet penetration (INTPEN) exerts a positive effect on economic growth which is not significant at the 5% level. On the other hand, a percentage growth of ICT investment (lnICTINV) decreases economic growth by 0.02 percentage points, contrary to expectation, and the result is significant at the desired 5% level. The control variables also have mixed results. While more gross capital formation (lnGCF) contributes to economic growth, labour force growth (lnLBF) exerts a negative pressure on the GDP per capita, with both result significant at the 5% level. Lastly, institutional quality (REGQ) appears to have a positive effect on economic growth but the result is not significant at the desired level, even at the first lag. However, its second lag (REGQ-2) has a significant positive influence on current level of economic growth. Overall, the short-run model has a speed of adjustment (toward long-run equilibrium) of about 14% per annum. Though slow, the error correction coefficient is significant at the 5% level, implying that the model possesses the ability to return to a steady-state following a turbulent period that disturbed the state of rest.

(ii) ARDL long-run result

Table 4: ARDL Bounds test result

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	14.96491	10%	1.99	2.94
K	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99

Source: Researcher's computations from EViews 12 (2026)

The result in Table 4 shows that the F-statistic (14.96) is greater than the upper bounds [I(1)] critical value (3.28) at the 5% level of significance. This implies the rejection of the null hypothesis of no levels (long-run) relationship. Hence, the result suggests that the variables of the study have a long-run relationship. Consequently, we estimated the long-run relationship and goth the result below.

Table 5: ARDL long-run (levels equation) result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnMOBP	0.212114	0.148952	1.424044	0.1749
INTPEN	0.030151	0.026190	1.151274	0.2676
lnICTINV	-0.166698	0.186971	-0.891571	0.3867
lnGCF	-0.093907	0.183286	-0.512351	0.6159
lnLBF	-2.937050	2.820871	-1.041185	0.3143
REGQ	0.870442	0.790523	1.101097	0.2882
C	67.41624	51.98838	1.296756	0.2143

Source: Researcher's computations from EViews 12 (2026)

The result in Table 5 shows that growth of mobile cellular subscription (lnMOBP), internet penetration, and better regulatory quality (REGQ) tend to contribute to the long-run economic

growth (lnGDPPC) but the impacts are not significant at the 5% level. Same applies to ICT investment (lnICTINV) and labour force growth, both of which have negative signs. The result implies that long-run growth of the Nigerian economy is not heavily tied to the ICT variables and the control variables used in this study.

4.4 Model diagnostics

We checked the robustness of the estimated model using conventional post-estimations tests such as autocorrelation, heteroskedasticity, normality, and stability tests.

(i) Autocorrelation test result

Table 6: Breusch-Godfrey Serial correlation LM test result

Statistic	Coefficient		P-value
F-statistic	3.297635	Prob. F(2,13)	0.1075
Obs*R-squared	5.28043	Prob. Chi-Square(2)	0.0928
Null hypothesis: No serial correlation at up to 2 lags			

Source: Researcher's computations from EViews 12 (2026)

The result in Table 6 shows that the p-values of the F-statistic and the Chi-sq. are larger than 0.05, which means acceptance of the null hypothesis of no serial correlation up to 2 lags. The result gives evidence of absence of autocorrelation (linear dependence of the residuals of successive sub-samples in the series) in the estimated model.

(ii) Heteroskedasticity test result

Table 7: Heteroskedasticity Test: ARCH

F-statistic	1.560810	Prob. F(2,22)	0.2323
Obs*R-squared	3.106508	Prob. Chi-Square(2)	0.2116

Source: Researcher's computations from EViews 12 (2026)

The result in Table 7 shows that the p-values of the F-statistic and that of the Chi-sq are greater than 0.05. Hence, we do not reject the null hypothesis of no heteroskedasticity, which means that the residuals of sub-samples from the series exhibit constant variance.

(iii) Histogram normality test

This is a statistical test of normality of the distribution of the regression residuals.

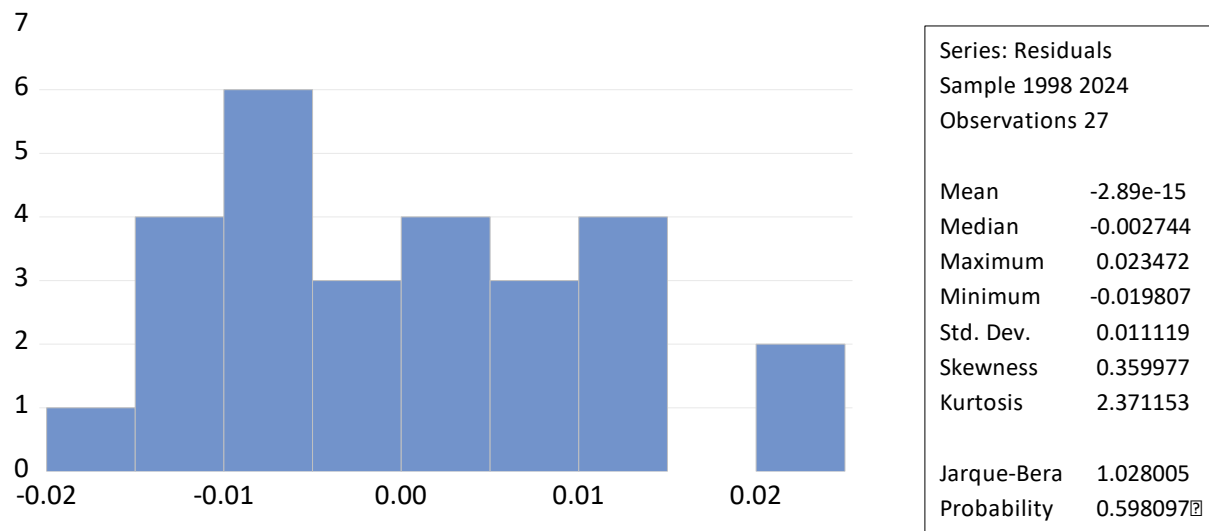


Fig. 1: Histogram normality test result

Source: Researcher's computations from EViews 12 (2026)

The result in Fig. 1 shows that the skewness is near zero, the kurtosis is less than 3, and the p-value of the Jarque-Bera statistic is greater than 0.05. Hence, the null hypothesis that the residuals are normally distributed is upheld which is in tandem with our expectations.

(iv) Ramsey RESET test result

Table 8: Ramsey RESET Test result

	Value	df	Probability
t-statistic	1.231943	14	0.2383
F-statistic	1.517683	(1, 14)	0.2383
Likelihood ratio	2.778917	1	0.0955

Source: Researcher's computations from EViews 12 (2026)

This is a stability test used to determine whether the model was correctly specified in the linear format, or whether it should include squares of some variables, in which case it would become non-linear in variables. The result in Table 8 shows that the p-values of the t and F statistics are greater than 0.05 which indicates that including the squares of omitted variables will not significantly improve the model. The result implies that the estimated model is stable.

(v) Recursive tests

We also administered another kind of stability test, this time, the recursive tests such as the cumulative sum (CUSUM) test and the recursive coefficients test shown in Figs. 2 and 3.

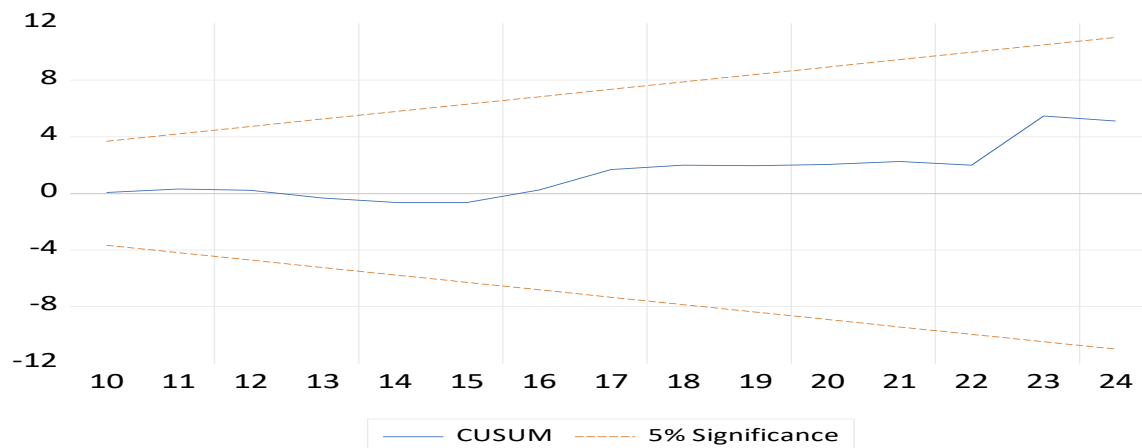


Fig. 2: CUSUM test result

Source: Researcher's computations from EViews 12 (2026)

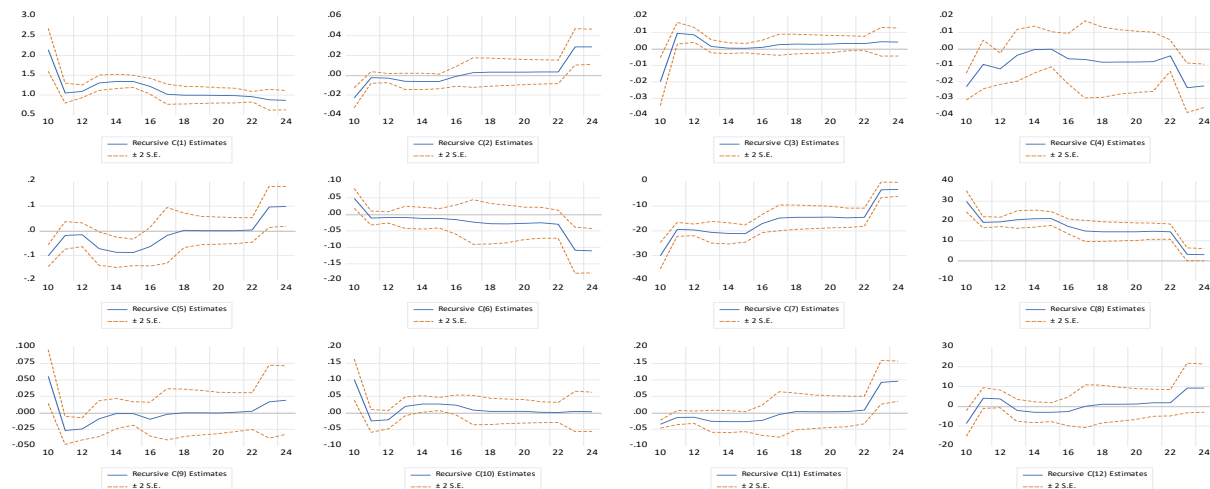


Fig. 3: recursive coefficients test result

Source: Researcher's computations from EViews 12 (2026)

The result in Figs. 2 and 3 show that the equation lines of the estimated relationship continue with the 5% critical bounds which imply stability in the forecasted relationship. Particularly, Fig. 3 shows a group of 14 graphs comparing Mean Q2 forecasts (smooth line) against the Robust Factor Analysis for Tensor Time Series (RTFA) curve (dotted) across different variables or conditions. Each graph spans the same x-axis range (–24 to 24), while the y-axis varies depending on the metric being plotted. The graph is used to determine consistency across group from the layout. For instance, one can easily spot where the forecast (smooth line) tracks closely or diverges with RTFA (broken lines). Overall, there is no such divergence in the Fig. 3 which gives evidence that the model is stable, fit for forecast.

4.5 KRLS result

We conducted further analysis of the study data using the kernel regularised least squares (KRLS) method for two reasons. First, the ARDL long-run results are all statistically insignificant implying

that the ICT variables and economic growth nexus is more pronounced in the short run. However, the short-run ARDL result returned estimates that are contrary to expectations, particularly in relation to ICT investment and labour force (both negative). KRLS in this study the, therefore, serves as an alternative estimation ARDL result. Secondly, the KRLS method corrects for the functional form of the model making it appropriate for a linear regression. Hence, the estimates are regarded as long-run regression coefficients.

Table 9: KRLS estimates

Ingdppc	Avg.	t	P> t	P25	P50	P75
lnmobp	.007251	9.962	0.000	.000737	.005644	.014426
intpen	.00172	11.423	0.000	.000021	.000652	.003834
lnictinv	.013562	5.016	0.000	-.00151	.007715	.018795
lngcf	.009888	3.294	0.003	-.003864	.008875	.021962
lnlbf	.078819	6.829	0.000	-.035524	.060904	.163049
regq	.050738	2.460	0.022	-.067139	.120807	.207668

Source: Researcher's computations from STATA 16 (2026)

In Table 9, Avg. are the average partial derivatives of the dependent variable (log of GDP per capita) with respect to each independent variable. The average effect is determined from three-point estimates, namely, the 25, 50, and 75% quantiles (P25, P50, P75) which shows the distribution of the effects across the lower, median, and upper quartiles of the data. The estimates show how sensitive GDP per capita is to changes in each regressor. The results are short-run estimates as they are forged outside the error correction framework or lags. The result indicates that (i) growth of mobile phone/cellular subscriptions (lnMOBP), on the average, increases economic growth by 0.7 percentage points, significant at the 1% level which means that the impact is strong. Likewise, a percentage increase in internet penetration (INTPEN) in the population raises GDP growth by about 0.2 percentage points on per capita basis. The impact is also very strong ($p < 0.01$). For these two variables, the positive effects are sustained across the three quantiles.

As for ICT investment (ICTINV), a percentage growth contributes about 1.4 percentage point to the growth of GDP per capita in the short run, significant at the 1% level, showing a strong influence of the variable. However, the impact is negative within the lower quantile (P25) but increases across the middle and upper quantiles (P50 and P75). This reflects the result from the ARDL but provides a more holistic result due to accommodating a wider spectrum.

Regarding the control variables, gross capital formation, labour force growth, and regulatory quality all exert positive effects on the dependent variable with coefficients of 0.99, 7.9, and 5.0 percentage points, respectively. Similarly, each of these also rise from negative values at the lower quantile to positive across the median and upper quartile. In summary, the result shows that mobile penetration (proxied by growth of mobile cellular subscriptions), internet penetration, ICT investment, capital formation, labour force, and regulatory quality all significantly contribute to growth of GDP per capita in Nigeria.

We also used relevant statistics to evaluate the KRLS model. First, the goodness of fit (R^2) of is 0.9968. It means that the model explains almost all the variation in economic growth measured by log of GDP per capita. Second, the effective degrees of freedom (11.69) suggests that the model

is flexible but not overfitted. Third, the Looloss (0.1099) signifies negligible out-of-sample prediction error, suggesting strong predictive performance of the model.

4.6 Test of hypothesis

We used the ARDL and the KRLS results to test the three null hypotheses of the study because it exhibits better statistical properties than the ARDL counterpart.

(i) Null hypothesis 1: Mobile phone subscription has no significant impact on economic growth in Nigeria.

The ARDL result in Table 3 shows that the coefficient of mobile phone subscription (lnMOBP) is 0.03 ($t = 3.22$, $p = 0.006$). Likewise, the KRLS result in Table 9 shows that the coefficient of the variable is 0.0073 ($t = 9.962$, $p = 0.000$). Both results mean that the variable has a strong positive impact on economic growth measured as GDP per capita growth. As such, we reject the null hypothesis one at the 5% level and conclude that mobile phone penetration, in the form of growth of the number of mobile cellular subscriptions, has a positive and significant impact on economic growth in Nigeria.

(ii) Null hypothesis 2: Internet penetration has no significant impact on the Nigerian economy.

From the ARDL result in Table 3, the estimated regression coefficient of internet penetration (INTPEN) is 0.0041 ($t = 0.97$, $p = 0.35$). However, the KRLS result in Table 9 shows that the coefficient of the variable is 0.00172 ($t = 11.423$, $p = 0.000$) which means that the variable strongly contributes to the growth of GDP per capita. Hence, the null hypothesis under review stands rejected, with the outcome that greater internet penetration significantly enhances economic growth in the country.

(iii) Null hypothesis 3: ICT investment has no significant impact on economic growth in Nigeria.

The KRLS result in Table 9 shows that the ICT investment (lnICTINV) variable has the coefficient 0.014 ($t = 5.016$, $p = 0.000$). This means that economic growth is strongly linked to growth in ICT investment, as expected. Based on this result, we reject the null hypothesis three which implies that ICT investment has a positive and significant impact on economic growth in Nigeria.

5. Conclusion and Recommendations

Based on the regression results, the study concludes that mobile phone penetration, internet penetration, and ICT investment all have statistically significant positive impacts on Nigeria's economic growth, measured by GDP per capita. Relatively, ICT investment has the strongest impact, followed by mobile penetration and internet penetration, highlighting the critical role of digital infrastructure and connectivity in driving economic progress. These findings suggest that policies aimed at expanding mobile access, deepening internet penetration, and increasing ICT-related investments can substantially spur Nigeria's growth trajectory. Hence, the study concludes that strengthening the digital economy is not just complementary but essential for sustainable economic progress in a developing country like Nigeria. Hence, the Nigerian government should encourage wider and more affordable mobile access by reducing tariffs and supporting telecom

operators to expand coverage into rural and underserved areas. This ensures that mobile subscriptions translate into real economic activity rather than just numbers. It is also imperative that the Nigerian government and private sector should invest in broadband infrastructure and community-based internet initiatives, such as public Wi-Fi in schools, markets, and rural towns. Affordable, reliable internet will allow more citizens to participate in the digital economy and boost productivity across sectors. Furthermore, the federal government of Nigeria should create a supportive environment for ICT investments by offering tax incentives, improving electricity supply, and strengthening regulatory frameworks. It is also necessary to channel funds into ICT startups and digital infrastructure projects to foster innovation and long-term growth.

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