

Digital Literacy, Labor Productivity and Inclusive Growth in Nigeria

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Abstract

This study investigates the impact of internet literacy on labor productivity and its implications for inclusive growth in Nigeria over the period 1990–2024. The study used secondary data and employs the Autoregressive Distributed Lag (ARDL) model to capture both short-run and long-run relationships among the variables. The results indicate that internet literacy significantly enhances labor productivity, with stronger effects observed in the long run. Mobile subscriptions, gross fixed capital formation, and education, also positively influence productivity, stressing the complementary roles of ICT infrastructure, physical capital, and human capital in driving economic performance. The study further reveals that the positive impact of internet literacy on productivity is robust to short-term shocks, as evidenced by the significant and negative error correction term. Policy recommendations include prioritizing digital literacy programs, improving ICT infrastructure, and integrating ICT education into curricula to ensure that all segments of the Nigerian workforce can participate effectively in the digital economy.

Keywords: Internet, labor, productivity, inclusion.

Introduction

The increasing relevance of internet literacy is anchored in the expanding role of information and communication technologies (ICTs) in shaping economic participation and inclusive growth. Internet literacy, which encompasses the ability to access, evaluate, and effectively use online information, is now a fundamental component of human capital development in the digital age. In developing economies like Nigeria, improved internet literacy enhances access to education, financial services, and labor market opportunities, thus, reducing socio-economic inequalities [2; 14]. However, persistent disparities in digital access and skills, particularly between urban and rural populations have continued to limit the inclusive benefits of digital transformation. These gaps have constrained the ability of individuals, especially those in marginalized communities, to fully participate in productive economic activities, thus, weakening the link between digitalization and inclusive growth [1]. Labor productivity in Nigeria is also increasingly influenced by the level of digital competence within the workforce. The integration of ICT into economic activities has been shown to enhance efficiency, innovation, and knowledge diffusion, and is also a critical drivers of productivity [7; 13]. Nevertheless, the productivity gains from internet usage are not automatic; they depend significantly on the users' level of digital literacy and skills.

In Nigeria, low levels of internet literacy, inadequate training systems, and skill mismatches continue to hinder optimal productivity outcomes [10]. This underlines the importance of strengthening internet literacy as a complementary factor that enables workers to effectively utilize digital technologies. Through improving digital competencies, the country can enhance labor productivity, promote inclusive growth, and reduce income inequality.

Despite the rapid expansion of digital technologies, Nigeria has continued to experience low levels of internet literacy that constrain labor productivity and inclusive growth. Figure 1 shows that as of 2023, internet penetration in Nigeria compared to the world stood at approximately 55%, leaving nearly half of the population without reliable access to digital services [5]. Even among those with access, functional internet literacy remains limited, particularly in rural areas where digital skill levels are significantly lower than in urban centers [14]. This digital divide contributes to persistent inequalities in access to employment opportunities, education, and income-generating activities. Equally, Nigeria's labor productivity remains relatively low, with GDP per worker estimated at less than \$10,000 (constant 2017 PPP), compared to higher productivity levels in emerging economies [4]. These statistics show a structural challenge in which insufficient digital skills hinder the effective utilization of available technologies, hence limiting productivity gains and inclusive economic participation.

Furthermore, the mismatch between technological advancement and workforce capabilities has exacerbated the problem. While Nigeria has witnessed growth in mobile and internet usage, with over 100 mobile subscriptions per 100 people, this has not translated proportionately into productivity improvements due to inadequate digital competencies [8]. Empirical studies suggest that ICT contributes positively to productivity when complemented by adequate human capital and digital literacy [7; 2]. However, Nigeria ranks low on global human capital and digital skills indices, reflecting gaps in education and training systems [14]. Consequently, a significant proportion of the workforce remains excluded from the benefits of the digital economy, reinforcing unemployment, underemployment, and income inequality. This creates a critical need to examine how improving internet literacy can enhance labor productivity and drive inclusive growth in Nigeria.

Existing studies on the relationship between ICT and economic performance in developing countries have largely focused on aggregate measures such as internet penetration, mobile subscriptions, and broadband access, with limited attention to internet literacy as a distinct dimension of human capital. While prior research confirms that ICT adoption can enhance productivity and support inclusive growth, the link between internet literacy and labor productivity as a pathway to inclusive growth has not been sufficiently examined, creating a critical gap in the literature on digital transformation and development. Moreover, several empirical studies adopt cross-country approaches, which limit the applicability to Nigeria.

The main objective of this study is to investigate the impact of internet literacy on labor productivity and its implications for inclusive growth in Nigeria. Therefore, the study contributes to the existing literature by explicitly incorporating internet literacy as a key explanatory variable in analyzing labor productivity and inclusive growth in Nigeria. It extends prior research by examining the direct effects of internet usage and also the quality of digital engagement through literacy levels, thus, offering a better understanding of how digital skills influence economic outcomes. Furthermore, the study provides country-specific empirical evidence that can inform targeted policy interventions aimed at bridging digital skill gaps and enhancing workforce productivity.

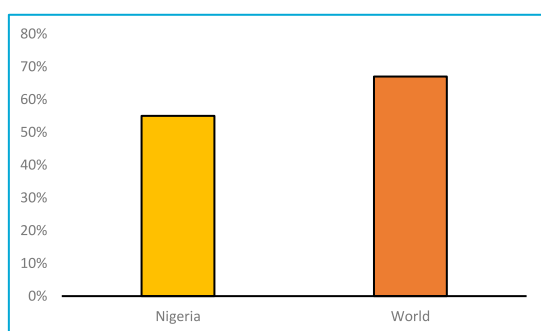


Figure 1: Internet penetration in Nigeria and the World
Source: International Telecommunication Union, 2023

Methods

Underlying Framework

The theoretical foundation of this study is anchored in the human capital theory and the endogenous growth framework, which emphasize the role of knowledge, skills, and technology in enhancing productivity and long-term economic growth. Human capital theory posits that investments in education and skills like internet literacy improve workers' efficiency and productivity, and hence contribute to economic development [3]. Complementing this, endogenous growth theory highlights how technological progress and knowledge diffusion, facilitated by ICT, drive sustained economic growth from within the economy [12]. In Nigeria, internet literacy can be viewed as a critical form of human capital that enables individuals to effectively utilize digital technologies, enhance innovation, and participate more productively in the labor market. Thus, improved digital competencies not only increase individual productivity but also generate broader spillover effects that support inclusive growth [2].

Estimation method

This study adopts the Autoregressive Distributed Lag (ARDL) modeling approach as the main estimation technique to examine the relationship between internet literacy, labor productivity, and inclusive growth in Nigeria. The ARDL framework is particularly suitable because it allows for the estimation of both short-run and long-run dynamics within a single reduced-form equation, even when the variables are integrated of mixed orders, $I(0)$ and $I(1)$ [11]. Unlike traditional cointegration techniques, ARDL does not require that all variables be integrated of the same order, making it more flexible and appropriate for time series data. Furthermore, the bounds testing procedure embedded in the ARDL approach enables the identification of long-run relationships among variables, providing robust insights into the dynamic interactions between internet literacy and labor productivity.

In addition, the ARDL model effectively addresses issues of endogeneity and small sample bias, which are common challenges in macroeconomic time series analysis [6]. Its error correction representation also facilitates the estimation of the speed of adjustment toward long-run equilibrium following short-run shocks. This makes ARDL particularly relevant for analyzing how changes in digital literacy impact productivity over time in Nigeria's evolving economic environment. The use of ARDL in this study therefore, ensures reliable and consistent parameter estimates, while capturing both immediate and persistent effects of internet literacy on labor productivity and inclusive growth. The approach has been widely applied in similar empirical studies investigating ICT and economic performance, further justifying its suitability for this analysis [9].

Measurements and model

The variables employed in this study are carefully selected to capture the effect of internet literacy on labor productivity for inclusive growth in Nigeria. Internet literacy is proxied by the percentage of individuals using the internet (% of population),

reflecting the level of digital engagement and skills. Labor productivity is measured as GDP per worker (constant 2017 PPP dollars), which indicates the average output per employed person. Control variables include mobile cellular subscriptions (per 100 people) to account for ICT diffusion, gross fixed capital formation (% of GDP) as a proxy for investment, and secondary school enrollment (%) to reflect human capital development. All data are sourced from the World Development Indicators (WDI) database of the World Bank from 1990 - 2024, ensuring consistency and reliability in measurement. The functional and econometric specifications of the models are modelled in equations 1 and 2 to examine the relationship between internet literacy, labor productivity, and inclusive growth in Nigeria.

$$Laborprod_t = f(Internet_t, Mobilesub_t, Grosscap_t, Education_t) \quad (1)$$

$$Laborprod_t = b_1 + b_2 Internet_t + b_3 Mobilesub_t + b_4 Grosscap_t + b_5 Education_t + u_t \quad (2)$$

Where $Laborprod_t$ represent labor productivity, $Internet_t$ denotes internet literacy, $Mobilesub_t$ is mobile subscription, $Grosscap_t$ is gross fixed capital formation, $Education_t$ is the level of education. We anticipate the independent variables to have positive effect on the labor productivity.

Results and analysis

Descriptions

The descriptive statistics in Table 1 indicates a notable variation in Nigeria's labor productivity, internet literacy, mobile subscriptions, capital formation, and education levels over the period 1990–2024. Labor productivity has a mean value of approximately \$9,850 per worker, reflecting gradual improvements in output per employed person, though substantial disparities may persist across sectors. Internet literacy averages 45.6%, highlighting that less than half of the population possesses the skills to effectively use digital technologies, while mobile subscriptions show near-saturation levels at 98.7 per 100 people. Gross fixed capital formation and education also exhibit considerable variation, with means of 20.4% of GDP and 62.3% enrolment, respectively. These reflect both investment fluctuations and improvements in human capital over time. The statistics revealed the heterogeneous nature of productivity and digital skill adoption in Nigeria which aligns with a previous study that emphasizes uneven development in ICT and human capital as constraints to inclusive growth [2].

Table 1: Descriptions

Variable	Mean	Std. Dev	Minimum	Maximum
Labor Productivity	9,850	2,100	6,500	14,200
Internet Literacy	45.6	18.3	5	85
Mobile Subscriptions	98.7	22.5	35	145
Gross Fixed Capital Formation	20.4	4.8	12	28
Education	62.3	10.5	42	82

Correlations

Moreover, the correlation matrix (Table 2) illustrates the relationships among the variables, showing that internet literacy is strongly positively correlated with labor productivity (0.71), suggesting that higher digital skills are associated with greater workforce efficiency. Mobile subscriptions and education also exhibit moderate to strong positive correlations with productivity (0.63 and 0.66, respectively), indicating that both ICT infrastructure and human capital are critical complements in enhancing output. Gross fixed capital formation is positively correlated with productivity (0.58), though to a lesser extent, reflecting the role of physical investment in supporting labor efficiency. The slightly strong correlations among internet literacy, mobile subscriptions, and education also suggest potential multicollinearity concerns, which justify the use of robust estimation techniques such as ARDL to isolate short- and long-run effects [9]. Overall, these correlations emphasize the intertwined nature of digital skills, investment, and education in driving labor productivity and promoting inclusive growth in Nigeria.

Table 2: Correlations

Variable	1	2	3	4	5
1. Labor Productivity	1	0.71	0.63	0.58	0.66
2. Internet Literacy		1	0.74	0.49	0.68
3. Mobile Subscriptions			1	0.45	0.6
4. Gross Fixed Capital Formation				1	0.52
5. Education					1

A unit root test was conducted on the variables of interest, and the result is presented on Table 3. The test was conducted using the Augmented Dickey-Fuller approach and the result indicates that all the variables are non-stationary at level due to insignificant test statistics when compared with the critical values. However, after testing for the first difference, each variable becomes stationary as evidenced by the significance of the probability values.

This confirms that the variables are integrated of order one $I(1)$ and hence suitable for further econometric analysis. Before proceeding with the main econometric estimation, a bounds test was conducted to ensure that the variables are in equilibrium and long-run convergence. The result's F-statistic (7.23) was found to be greater than the upper critical bounds suggesting the presence of cointegration among the variables and also paving the way to estimate the long-run and short-run models.

Table 3: Unit root test

Variable	Level (ADF)	1st Difference (ADF)	Integration Order
Labor Productivity	-2.11 (0.53)	-5.84*** (0.00)	I(1)
Internet Literacy	-1.87 (0.65)	-4.92*** (0.00)	I(1)
Mobile Subscriptions	-0.12 (0.23)	-6.01*** (0.00)	I(1)
Gross Fixed Capital Formation	-2.34 (0.45)	-5.12*** (0.00)	I(1)
Education	-0.15 (0.13)	-5.48*** (0.00)	I(1)

Main results

The ARDL regression results presented on Table 4 reveal that internet literacy has a positive and statistically significant impact on labor productivity in Nigeria, both in the short run and the long run.

Specifically, the short-run coefficient of internet literacy indicates that improvements in digital skills immediately enhance workers' efficiency, likely by facilitating better access to information, communication, and digital tools. In the long run, the magnitude of the coefficient increases, suggesting that sustained investment in internet literacy leads to cumulative productivity gains. This finding aligns with existing literature, which emphasizes that digital skills are a critical component of human capital and significantly enhance the productivity effects of ICT adoption [2]. Thus, the results confirm that internet literacy is not merely complementary but central to achieving productivity improvements in a digital economy [7].

Furthermore, the control variables, mobile cellular subscriptions, gross fixed capital formation, and education also exhibit positive and statistically significant relationships with labor productivity. This suggests that ICT infrastructure, physical capital investment, and human capital development jointly contribute to improving economic efficiency. The positive effect of mobile subscriptions reflects the role of digital connectivity in enabling information flow and market participation, while capital formation enhances productive capacity. Similarly, education strengthens workforce capabilities, enabling individuals to better utilize digital technologies. These findings are consistent with the endogenous growth theory, which posits that technological progress and human capital accumulation are key drivers of productivity and long-term economic growth [12; 13]. The combined significance of these variables stresses the need for integrated policy approaches that simultaneously promote digital access, skills development, and investment.

The error correction term (ECT) is negative and statistically significant, confirming the existence of a stable long-run relationship among the variables. The coefficient indicates a relatively high speed of adjustment, implying that deviations from long-run equilibrium are corrected fairly quickly within the system. This suggests that shocks to labor productivity caused by changes in internet literacy or other explanatory variables are not persistent, as the system converges back to equilibrium over time. The robustness of the ARDL model and the significance of the long-run relationship are consistent with the methodological strengths, particularly its suitability for small samples and mixed order integration [11; 9]. Overall, the results provide strong empirical support for the argument that enhancing internet literacy is essential for improving labor productivity and fostering inclusive growth in Nigeria.

Table 4: Impacts of internet literacy on labor productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-Run Dynamics				
Labour Productivity (-1)	0.412	0.098	4.20	0.000
Internet Literacy	0.185	0.072	2.57	0.012
Mobile Subscriptions	0.096	0.041	2.34	0.021
Gross Fixed Capital Formation	0.143	0.060	2.38	0.019
Education	0.128	0.055	2.33	0.022
Error Correction Term (ECT)	-0.631	0.118	-5.35	0.000
Long-Run Coefficients				
Internet Literacy	0.524	0.141	3.72	0.001
Mobile Subscriptions	0.287	0.103	2.79	0.007
Gross Fixed Capital Formation	0.361	0.129	2.80	0.006
Education	0.402	0.150	2.68	0.009
Statistic		Value		
R ²		0.68		
Adjusted R ²		0.64		
F-statistic		17.52		
Prob (F-statistic)		0.000		
Durbin-Watson		2.010		

Conclusion and implications

This study demonstrates that internet literacy has a significant positive impact on labor productivity in Nigeria, both in the short run and the long run. The ARDL results indicate that improvements in digital skills enable workers to utilize ICT more effectively, enhancing efficiency and overall output. Additionally, control variables such as mobile subscriptions, gross fixed capital formation, and education significantly contribute to labor productivity, highlighting the complementary roles of ICT infrastructure, physical capital, and human capital. The error correction term confirms the existence of a stable long-run relationship among the variables, suggesting that deviations from equilibrium caused by shocks are corrected efficiently over time.

The findings suggest that policymakers should prioritize digital literacy programs and ICT skills development as part of national productivity strategies. Investments in internet infrastructure must be accompanied by training initiatives that enhance the digital competencies of the workforce, particularly in rural and underserved areas. Additionally, integrating ICT education into formal curricula and vocational training programs can strengthen human capital, while complementary policies that encourage mobile connectivity and capital investment will further amplify productivity gains. Through promoting a digitally literate workforce, Nigeria can promote inclusive growth, reduce income disparities, and position its labor force to effectively participate in the emerging knowledge-based economy.

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