

Connected Intelligence Technological Innovation for Industrial Productivity (Evidence From Nigeria's Economic Transition)

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Abstract

This study examines the role of connected intelligence, proxied by digital connectivity, in enhancing industrial productivity in a developing economy, with specific reference to Nigeria. Anchored in the development economics and digital economy literature, industrial application is measured by gross domestic product (GDP) growth, while digital connectivity is captured by mobile internet subscriptions. Regulatory quality is included as a proxy for industrial reforms, and technological innovation—measured by information and communication technology (ICT) service exports is incorporated as a moderating variable. Quarterly time-series data covering 1996Q1–2024Q4 are analyzed using the Autoregressive Distributed Lag (ARDL) technique to estimate both short-run dynamics and long-run relationships. The empirical findings indicate that digital connectivity exerts a positive and statistically significant effect on industrial application in both the short and long run. Regulatory quality also demonstrates a positive influence, confirming the importance of effective industrial reforms. Furthermore, the interaction between mobile internet subscriptions and ICT service exports reveals that technological innovation significantly strengthens the productivity-enhancing impact of digital connectivity. The study concludes that connected intelligence is a critical driver of industrial productivity in Nigeria. Accordingly, it recommends prioritizing investment in digital infrastructure, expanding affordable mobile internet access, promoting ICT-driven innovation, and strengthening regulatory frameworks to maximize the developmental benefits of digital connectivity and foster sustainable industrial growth.

Keywords: *Connected Intelligence; Industrial Productivity; Technological Innovation; Regulatory Quality; Nigeria.*

INTRODUCTION

Industrial productivity is a core concern in development economics, especially for developing countries that aim to achieve sustainable growth, create jobs, and undergo structural transformation. A more productive industrial sector increases value addition, supports export diversification, and reduces over reliance on primary commodities (Rodrik, 2016). In Nigeria, where growth has been volatile and heavily dependent on oil, raising industrial productivity is essential for achieving inclusive and resilient development (Adenikinju & Olofin, 2020).

Beyond digital infrastructure, industrial performance is strongly shaped by institutional and regulatory conditions. Industrial reforms, reflected in the quality of regulation, influence the business environment by affecting the ease of firm entry, the intensity of competition, the pace of innovation, and the cost of compliance (North, 1990; Acemoglu & Robinson, 2012). Weak regulatory institutions can erode the productivity gains from digital technologies by limiting private sector development and discouraging investment. In contrast, well designed regulatory reforms can complement digital connectivity by creating an environment that supports industrial expansion and technology adoption (World Bank, 2020).

In recent decades, the global economy has undergone a profound digital transformation

driven by rapid advances in information and communication technologies (ICTs). Digital connectivity, particularly access to mobile internet, has emerged as a key driver of productivity growth by improving information flows, lowering transaction costs, enhancing firm level efficiency, and facilitating innovation (Brynjolfsson & McAfee, 2014; World Bank, 2016). Within the digital economy framework, connected intelligence enables firms and industries to integrate digital tools into production processes, logistics, marketing, and supply chains, thereby strengthening industrial performance (UNCTAD, 2019).

Technological innovation represents another critical channel through which digital connectivity affects industrial productivity. In the digital economy, innovation is increasingly embodied in ICT based services and digital exports. ICT service exports reflect a country's capacity to generate, apply, and commercialize digital knowledge, thereby enhancing industrial competitiveness and productivity (Grossman & Helpman, 1991; UNIDO, 2020). The interaction between digital connectivity and technological innovation is therefore crucial, because connectivity alone may be insufficient to drive productivity without complementary innovation capabilities.

For developing economies, mobile internet connectivity plays a particularly important role due to its relatively low cost and wide accessibility compared with fixed broadband infrastructure. Empirical studies suggest that greater mobile internet penetration stimulates productivity by supporting digital entrepreneurship, improving access to markets, and enhancing coordination across industrial value chains (Qiang et al., 2009; Hjort & Poulsen, 2019). Despite Nigeria's rapid growth in mobile internet subscriptions over the past two decades, the extent to which digital connectivity has translated into improved industrial productivity remains an open empirical question.

Nigeria presents a compelling case for examining these relationships. Although the country has made notable progress in expanding mobile internet access and ICT services, industrial productivity has remained relatively weak, constrained by infrastructural deficits, regulatory challenges, and limited technological upgrading (Akinwale et al., 2018). This raises important policy relevant questions about whether digital connectivity has effectively supported industrial productivity and whether technological innovation strengthens this impact.

Against this backdrop, this study investigates the impact of digital connectivity on industrial productivity in Nigeria, while accounting for the roles of regulatory quality and technological innovation. Industrial productivity is proxied by GDP growth rate, digital connectivity by mobile internet subscriptions, industrial reforms by regulatory quality, and technological innovation by ICT service exports. Using quarterly data from 1996Q1 to 2024Q4, the study employs the Autoregressive Distributed Lag (ARDL) estimation technique to examine both short run dynamics and long run relationships among the variables. By incorporating a moderating framework, the study contributes to the literature by assessing whether technological innovation amplifies the productivity effects of digital connectivity in a developing economy context.

2. LITERATURE REVIEW

2.1 Conceptual Framework of the Study

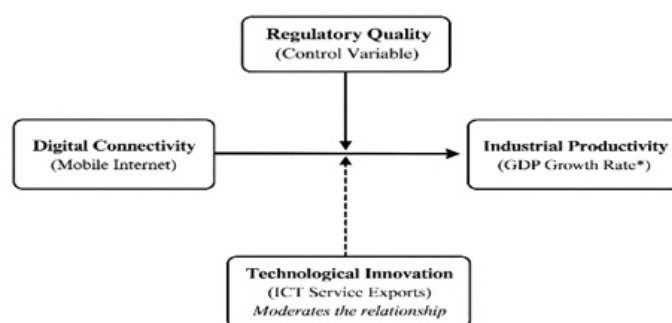


Figure 2.1

Figure 2.1: Presents the conceptual framework underpinning this study. The conceptual framework positions industrial productivity as the dependent variable, proxied by GDP growth rate. Digital connectivity, measured by mobile internet subscriptions, is the main explanatory variable and is expected to exert a positive influence on industrial productivity. Regulatory quality is included as a control variable because an enabling institutional environment facilitates industrial development and improves the effectiveness of digital technologies. Technological innovation, measured by ICT service exports, is introduced as a moderating variable to examine whether innovation capability strengthens the relationship between digital connectivity and industrial productivity. The framework draws on Endogenous Growth Theory, Schumpeterian Innovation Theory, and Institutional Theory, which together suggest that digital infrastructure, innovation, and sound institutions interact to enhance productivity and long run economic performance.

2.1.1 Industrial Productivity

Industrial productivity refers to the efficiency with which industrial inputs are transformed into outputs over a given period. In developing economies, it is often viewed as a key driver of structural transformation, economic diversification, and long term growth (Rodrik, 2016). Higher industrial productivity enables economies to achieve economies of scale, enhance competitiveness, and generate quality employment. At the macroeconomic level, industrial productivity is frequently proxied by indicators such as industrial output growth, manufacturing value added, or overall GDP growth rate, particularly in developing economies where industrial activities significantly influence aggregate economic performance (Szirmai, 2012). In Nigeria, industrial productivity has remained relatively low despite abundant labor and natural resources. Structural bottlenecks, infrastructure deficits, weak institutions, and limited technological adoption have

constrained the industrial sector's contribution to economic growth (Adenikinju & Olofin, 2020). Improving productivity is therefore central to Nigeria's industrialization and development agenda.

2.1.2 Digital Connectivity (Connected Intelligence)

Digital connectivity, also referred to as connected intelligence, captures the extent to which individuals, firms, and industries are connected through digital networks that facilitate information exchange and data driven decision making. Mobile internet subscriptions are widely used as a proxy for digital connectivity in developing economies due to the dominance of mobile platforms over fixed broadband infrastructure (World Bank, 2016). From a digital economy perspective, increased digital connectivity reduces information asymmetry, lowers transaction costs, enhances coordination, and improves access to markets and productive resources (Brynjolfsson & McAfee, 2014). For industrial firms, mobile internet access supports supply chain management, digital payments, e commerce, and process automation, thereby improving productivity and competitiveness (UNCTAD, 2019).

2.1.3 Industrial Reforms and Regulatory Quality

Industrial reforms encompass policy and institutional measures aimed at improving the business environment, promoting competition, and enhancing efficiency within the industrial sector. Regulatory quality reflects the government's ability to design and implement sound regulations that support private sector development (Kaufmann et al., 2011). Strong regulatory frameworks facilitate investment, innovation, and technology adoption by reducing uncertainty and compliance costs. Conversely, weak regulatory quality can undermine industrial productivity by discouraging firm entry and limiting the

effectiveness of digital and technological investments (North, 1990; Acemoglu & Robinson, 2012).

2.1.4 Technological Innovation

Technological innovation refers to the development, adoption, and diffusion of new technologies that enhance productive capacity. In the digital economy, innovation increasingly takes the form of ICT based services, software development, and digital exports. ICT service exports are commonly used as a proxy for technological innovation, as they reflect a country's capability to generate and commercialize digital knowledge (UNIDO, 2020). Innovation is particularly important in amplifying the productivity effects of digital connectivity. Without complementary innovation capabilities, digital access alone may not translate into meaningful productivity gains (Aghion & Howitt, 2009).

2.2 Theoretical Review

This study is underpinned by several theoretical frameworks in development and industrial economics..

Endogenous Growth Theory emphasizes the role of technology, innovation, and human capital in driving long term economic growth (Romer, 1990). According to this theory, investments in digital connectivity and ICT innovation enhance productivity by increasing knowledge spillovers and improving production efficiency.

Schumpeterian Innovation Theory highlights innovation as the engine of industrial transformation and productivity growth. Schumpeter (1934) argues that technological change, driven by innovation and creative destruction, reshapes industrial structures and improves economic performance. In this context, ICT service exports reflect innovation led industrial upgrading.

Institutional Theory posits that economic performance depends critically on the quality of institutions and regulatory frameworks (North, 1990). Effective regulations enhance the productivity impact of technology by creating an enabling environment for investment and innovation. This supports the inclusion of regulatory quality as a control variable in analyzing industrial productivity.

2.3 Empirical Review

Empirical evidence on the relationship between digital connectivity and productivity generally supports a positive association. Qiang et al. (2009) find that increased internet penetration significantly boosts economic growth and productivity, particularly in developing countries. Hjort and Poulsen (2019) show that access to fast internet in Africa leads to higher employment and firm productivity, especially in digitally intensive sectors. Studies focusing on mobile connectivity report similar findings, indicating that telecommunications infrastructure positively affects economic growth and that mobile phone diffusion improves productivity by reducing transaction costs in developing economies.

The role of regulatory quality has also been widely documented. Acemoglu and Robinson (2012) argue that strong institutions are fundamental for sustaining productivity growth. Empirical studies such as those by Kaufmann et al. (2011) show that regulatory quality significantly enhances economic and industrial performance by promoting efficiency and innovation. Regarding technological innovation, Grossman and Helpman (1991) provide early evidence that innovation driven exports improve productivity and growth. More recent studies indicate that ICT service exports contribute positively to industrial competitiveness and productivity in developing economies (UNIDO, 2020; UNCTAD, 2019).

In the Nigerian context, empirical evidence remains limited and mixed. Akinwale et al.

(2018) find that ICT development positively influences industrial growth, while Adenikinju and Olofin (2020) emphasize that regulatory and infrastructural constraints continue to limit productivity gains. Few studies, however, explicitly examine the moderating role of technological innovation in the digital connectivity–industrial productivity nexus using high frequency data.

More recent empirical studies have provided further evidence on the contribution of digital technologies to productivity across different economic settings. Ndubuisi et al. (2022) find that improvements in ICT quality significantly enhance technical efficiency and productivity, particularly in economies with greater digital readiness and supporting infrastructure. Similarly, Wen et al. (2022) show that digitalization positively influences total factor productivity, while effective environmental regulation further strengthens productivity gains by encouraging technological upgrading and efficient resource utilization. Zhang et al. (2022) report that broadband infrastructure significantly improves firm productivity through increased digital access, reduced information costs, and enhanced innovation activities.

The role of technological innovation has also been emphasized by Oke et al. (2022), who find that financial forces, absorptive capacity, and information sharing significantly improve innovation performance, thereby enhancing productivity and organizational competitiveness. In the Nigerian context, Yakubu and Lacheheb (2022) conclude that ICT development contributes positively to labor productivity and employment in the long run, although infrastructural and institutional challenges continue to limit the full realization of productivity gains. Likewise, the IMF (2024) concluded that digital adoption contributes significantly to labor productivity and industrial value added across Sub Saharan Africa, but the impact depends largely on complementary

investments in innovation, human capital, and institutional quality. These findings suggest that technological innovation may play an important moderating role in the relationship between digital connectivity and industrial productivity, thereby providing empirical support for the present study.

2.4 Literature Gap

Although existing studies recognize the importance of digital connectivity, regulation, and innovation for economic performance, several gaps remain. First, there is limited empirical evidence focusing on industrial productivity rather than aggregate economic growth in Nigeria. Second, most studies adopt linear frameworks and overlook the interaction between digital connectivity and technological innovation. Third, the use of quarterly data and the ARDL methodology remains underexplored in this context.

This study addresses these gaps by examining the direct and moderating effects of digital connectivity on industrial productivity in Nigeria using quarterly data from 1996Q1 to 2024Q4 and employing an ARDL framework. By integrating regulatory quality and technological innovation into the analysis, the study contributes to the growing literature on digital led industrial development in developing economies, particularly Nigeria.

2.5 Research Hypotheses: The hypotheses of this study are derived from the theoretical foundations and empirical evidence reviewed in the preceding sections. Endogenous Growth Theory posits that technological progress and digital infrastructure enhance productivity by improving knowledge diffusion and production efficiency (Romer, 1990). Similarly, Institutional Theory suggests that the effectiveness of digital technologies depends on the quality of the regulatory environment, while Schumpeterian Theory Innovation emphasizes that innovation strengthens industrial competitiveness through

technological advancement. Empirical studies have also consistently reported positive relationships between digital connectivity, technological innovation, regulatory quality and productivity (Qiang et al., 2009; Hjort & Poulsen, 2019; Ndubuisi et al., 2022; Wen et al., 2022; Zhang et al., 2022; Yakubu & Lacheheb, 2022). Drawing on these theoretical and empirical arguments, the following hypotheses are formulated to guide the empirical analysis.

H01: There is no significant relationship between digital connectivity and industrial productivity in Nigeria.

Digital connectivity, measured by mobile internet subscriptions, is expected to improve industrial productivity by facilitating access to information, reducing transaction costs, improving communication efficiency and supporting digital production processes. Previous empirical studies generally report that improvements in digital connectivity enhance productivity and economic performance across developing economies (Qiang et al., 2009; Hjort & Poulsen, 2019; Ndubuisi et al., 2022; Zhang et al., 2022). Accordingly, the first hypothesis examines whether digital connectivity significantly influences industrial productivity in Nigeria.

H02: Regulatory quality has no significant effect on industrial productivity in Nigeria.

Institutional Theory suggests that an effective regulatory environment promotes investment, technological adoption and industrial efficiency. Regulatory quality reduces uncertainty, improves the business environment and enhances the effectiveness of digital infrastructure. Empirical evidence indicates that economies with stronger regulatory frameworks generally experience higher productivity and industrial performance (Kaufmann et al., 2011; Wen et al., 2022). Consequently, this hypothesis evaluates whether regulatory quality contributes significantly to industrial productivity in Nigeria.

H03: Technological innovation does not significantly moderate the relationship between digital connectivity and industrial productivity in Nigeria. The productivity benefits of digital connectivity may depend on a country's capacity to generate and utilise technological innovations. Schumpeterian Innovation Theory argues that innovation enhances productivity by enabling firms to adopt new technologies and improve production processes. Empirical studies have similarly shown that innovation capability strengthens the effectiveness of digital technologies in promoting productivity and competitiveness (Oke et al., 2022; UNCTAD, 2023; IMF, 2024). Therefore, this hypothesis examines whether technological innovation, measured by ICT service exports, significantly moderates the relationship between digital connectivity and industrial productivity.

3. METHODOLOGY

3.1 Research Design

This study adopts a quantitative time-series research design to examine the relationship between digital connectivity, technological innovation, and industrial application in Nigeria. The design is appropriate for capturing both the short-run dynamics and long-run equilibrium relationships among macroeconomic variables over time. The empirical analysis is grounded in development and industrial economics, with emphasis on the digital economy and institutional factors influencing productivity.

3.2 Model Specification

To investigate the impact of digital connectivity on industrial productivity, the study specifies the following functional relationship:

$$IP_t = f(DC_t, RQ_t, TI_t, DC_t \times TI_t) \quad (1)$$

where: IP_t represents industrial application, proxied by GDP growth rate; DC_t denotes digital connectivity (connected intelligence), measured by mobile internet subscriptions; RQ_t captures industrial reforms, proxied by regulatory quality; TI_t represents technological innovation, proxied by ICT service exports; $DC_t \times TI_t$ is the interaction term capturing the

moderating effect of technological innovation on the relationship between digital connectivity and industrial application; t denotes time. The econometric model is expressed as:

$$GDPG_t = \beta_0 + \beta_1 MIST_t + \beta_2 RQ_t + \beta_3 ICTX_t + \beta_4 (MIST_t \times ICTX_t) + \epsilon_t \quad (2)$$

where ($GDPG_t$) is GDP growth rate, ($MIST_t$) is mobile internet subscriptions, (RQ_t) is regulatory quality, ($ICTX_t$) is ICT service exports, and (ϵ_t) is the error term.

3.3 Estimation Technique

The study employs the Autoregressive Distributed Lag (ARDL) modeling approach [13]. The ARDL technique is particularly suitable for this study for several reasons. First, it accommodates variables integrated of order $I(0)$ and $I(1)$, provided none is integrated of order $I(2)$. Second, it allows for the simultaneous estimation of short-run and long-run coefficients within a single framework. Third, ARDL is efficient for small and moderate sample sizes and reduces potential endogeneity concerns by incorporating appropriate lag structures.

3.4 Unit Root and Cointegration Tests

Prior to estimation, the stationarity properties of the variables are examined using conventional unit root tests such as the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests. These tests ensure that none of the variables is integrated of order $I(2)$, a necessary condition for the validity of the ARDL approach. To test for the existence of a long-run relationship among the variables, the ARDL bounds testing approach to integration is applied. The null hypothesis of no cointegration is tested against the alternative of a long-run relationship. Cointegration is confirmed if the computed F-statistic exceeds the upper critical bound provided by Pesaran et al. (2001).

4. RESULTS AND DISCUSSION

4.1 Unit Root Test Results

The Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests were employed to determine the stationarity properties of the variables. The results, presented in Table 4.1, indicate a mixed order of integration. GDP growth rate and regulatory quality are

stationary at level [$I(0)$], while mobile internet subscriptions, ICT service exports, and the interaction term become stationary after first differencing [$I(1)$].

Table 4.1: Unit Root Test Results

Variable	ADF Level	ADF 1st Diff.	Order
GDPG	-4.92***	—	$I(0)$
MIS	-1.41	-6.83***	$I(1)$
RQ	-3.87**	—	$I(0)$
ICTX	-1.96	-5.24***	$I(1)$
MIS $\times$ ICTX	-2.11	-6.09***	$I(1)$

*Note: **, ** denote significance at 1% and 5% levels respectively.

4.2 ARDL Bounds Test for Cointegration

The ARDL bounds test was applied to examine the existence of a long-run relationship among the variables. As shown in Table 4.2, the calculated F-statistic exceeds the upper bound critical value at the 5 percent level, confirming the presence of cointegration.

Table 4.2: ARDL Bounds Test Results

Test Statistic	Value
F- statistic	6.47
Lower Bound $I(0)$ (5%)	2.56
Upper Bound $I(1)$ (5%)	3.49

This result confirms a stable long-run equilibrium relationship between digital connectivity, technological innovation, regulatory quality, and industrial application in Nigeria.

4.3 Long-Run ARDL Estimation Results

Table 4.3 presents the estimated long-run coefficients. Mobile internet subscriptions exert a positive and statistically significant effect on industrial application, indicating that increased digital connectivity enhances GDP growth rate. Regulatory quality also has a positive and significant impact, underscoring the importance of industrial reforms. ICT service exports positively influence productivity, while the interaction term between digital connectivity and technological innovation is

positive and significant, confirming the moderating role of innovation.

Table 4.3: Long-Run ARDL Results

Variable	Co-efficient	Std. Error	t-Statistic	Probability
MIS	0.084***	0.021	4.00	0.000
RQ	1.762**	0.714	2.47	0.015
ICTX	0.531*	0.302	1.76	0.081
MIS × ICTX	0.019***	0.006	3.17	0.002
Constant	2.143	1.108	1.93	0.056

4.4 Short-Run Dynamics and Error Correction Model

The short-run dynamics are captured through the Error Correction Model (ECM), as reported in Table 4.4. The error correction term is negative and statistically significant, confirming convergence to long-run equilibrium. Approximately 62 percent of short-run disequilibrium is corrected within one quarter.

Table 4.4: Error Correction Model Results

Variable	Co-efficient	Std. Error	t-Statistic	Probability
ΔMIS	0.031**	0.014	2.21	0.029
ΔRQ	0.824**	0.372	2.22	0.028
ΔICTX	0.118	0.091	1.30	0.195
Δ(MIS × ICTX)	0.007*	0.004	1.89	0.061
ECM(-1)	0.623***	0.092	-6.77	0.000

4.6 Discussion of Results

The empirical results provide robust evidence that digital connectivity significantly enhances industrial productivity in Nigeria. The positive and statistically significant coefficient of mobile internet subscriptions indicates that improvements in digital connectivity stimulate industrial productivity by facilitating information exchange, reducing transaction costs, improving communication efficiency and supporting digital production processes. This finding is consistent with Qiang et al. (2009), who reported that increased internet penetration enhances productivity and economic growth in developing countries. It also agrees with Hjort and Poulsen (2019), who found that improved internet access significantly increases firm productivity and employment across Africa. More recent evidence by Ndubuisi et al. (2022) further confirms that improvements in ICT quality significantly enhance technical efficiency and productivity, while Zhang et al. (2022) similarly reported that broadband infrastructure positively influences firm productivity through improved digital access and innovation. The positive and statistically significant effect of regulatory quality suggests that improvements in institutional effectiveness and industrial reforms create an enabling environment for productivity growth. Effective regulatory systems reduce business uncertainty, promote investment and facilitate technology adoption within the industrial sector. This finding supports the institutional perspective advanced by Kaufmann et al. (2011) and is consistent with the empirical evidence of Wen et al. (2022), who found that effective regulatory policies complement digitalisation by enhancing total factor productivity through technological upgrading and improved resource allocation. The estimated coefficient of the interaction term between digital connectivity and ICT service exports is positive and statistically significant, confirming that technological innovation strengthens the productivity-enhancing effect of digital connectivity. This implies that digital infrastructure generates greater productivity gains when accompanied by stronger innovation capability and ICT

development. The finding is consistent with Oke et al. (2022), who reported that absorptive capacity, knowledge sharing and innovation significantly improve organisational performance and competitiveness. It also supports recent evidence from UNCTAD (2023) and the International Monetary Fund (2024), which conclude that the productivity benefits of digitalisation depend largely on complementary investments in innovation, institutional quality and technological capability. Overall, the findings provide empirical support for the Endogenous Growth Theory, Schumpeterian Innovation Theory and Institutional Theory, all of which suggest that digital infrastructure, innovation and supportive institutions jointly promote sustainable productivity growth.

Although the present findings support most previous studies, they differ from those reporting that the productivity effects of digital connectivity are constrained by inadequate infrastructure and weak institutional capacity in developing economies (e.g., Adenikinju & Olofin, 2020). The difference may be attributed to variations in sample period, methodology, proxy variables, and country-specific characteristics.

5.0. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study examined the effect of digital connectivity on industrial productivity in Nigeria by incorporating the roles of regulatory quality and technological innovation using quarterly data from 1996Q1 to 2024Q4 and the ARDL estimation technique. The findings confirmed a stable long-run relationship among the variables. Digital connectivity was found to exert a positive and statistically significant effect on industrial productivity, indicating that improvements in mobile internet access contribute to higher productivity. Regulatory quality also demonstrated a positive influence on industrial productivity, suggesting that an effective institutional environment enhances industrial performance. Furthermore, the interaction between digital connectivity and technological innovation was positive and statistically significant, confirming that technological innovation strengthens the

productivity-enhancing effect of digital connectivity. Overall, the study concludes that digital connectivity, supported by effective regulation and technological innovation, constitutes an important driver of industrial productivity in Nigeria.

5.2 Recommendations

Based on the empirical findings, the following recommendations are proposed:

5.2.1 Recommendation One (H01)

Since digital connectivity was found to have a significant positive effect on industrial productivity, the Federal Government of Nigeria and relevant stakeholders should prioritise investment in digital infrastructure by expanding affordable mobile internet coverage, particularly in underserved industrial and commercial areas. Such investments would enhance digital access, reduce transaction costs and improve industrial efficiency.

5.2.2 Recommendation Two (H02)

Given the significant positive influence of regulatory quality on industrial productivity, policymakers should strengthen regulatory reforms by promoting transparent, predictable and business-friendly policies that encourage private investment, technological adoption and industrial competitiveness. Regulatory agencies should also simplify administrative procedures and improve policy consistency to support industrial growth.

5.2.3 Recommendation Three (H03)

Since technological innovation significantly strengthens the relationship between digital connectivity and industrial productivity, government should complement digital infrastructure investments with policies that promote ICT innovation, digital entrepreneurship, research and development, ICT service exports and digital skills development. Strengthening innovation ecosystems will maximise the productivity benefits associated with digital connectivity.

This study examined the effect of digital connectivity on industrial application in Nigeria, incorporating the roles of regulatory quality and technological innovation using quarterly data from 1996Q1 to 2024Q4 and the

ARDL estimation technique. The findings confirmed the existence of a stable long-run relationship among the variables. Digital connectivity, measured by mobile internet subscriptions, was found to have a positive and statistically significant impact on industrial application in both the short and long run. Regulatory quality also contributed positively to productivity, highlighting the importance of industrial reforms and institutional effectiveness. In addition, technological innovation, proxied by ICT service exports, was found to significantly enhance the productivity gains from digital connectivity, indicating that innovation plays a critical moderating role in the digital–industrial nexus.

Based on these findings, the study recommends sustained investment in digital infrastructure to expand affordable mobile internet access across industrial sectors, alongside policies that promote ICT-driven innovation and export capacity. Strengthening regulatory quality through consistent, transparent, and business-friendly reforms is also essential to create an enabling environment for industrial productivity growth. An integrated policy framework that aligns digital economy initiatives with industrial and innovation strategies will be crucial for maximizing the productivity benefits of digital connectivity and fostering sustainable economic development in Nigeria.

5.3.1 Theoretical Implications

The findings of this study provide important theoretical implications for the literature on digital economy and industrial development. First, the study extends the Endogenous Growth Theory by demonstrating that digital connectivity contributes to industrial productivity through improved access to information and digital infrastructure. Second, the significant moderating effect of technological innovation provides empirical support for Schumpeterian Innovation Theory, suggesting that innovation capability enhances the productivity benefits derived from digital connectivity. Third, the positive effect of regulatory quality reinforces Institutional Theory by showing that effective regulatory frameworks create an enabling environment for digital technologies to translate into

productivity gains. By integrating digital connectivity, regulatory quality and technological innovation within a single empirical framework, the study contributes to the growing literature on digital-led industrial development in developing economies, particularly Nigeria.

5.3.2 Practical and Policy Implications

The findings have important implications for policymakers, regulatory agencies and industry stakeholders. The positive relationship between digital connectivity and industrial productivity suggests that expanding affordable mobile internet infrastructure should remain a national development priority. Government should therefore continue investing in broadband expansion, digital infrastructure and policies that promote universal internet access. The positive role of regulatory quality indicates the need for transparent, consistent and business-friendly regulatory reforms capable of encouraging private investment and technological adoption. Furthermore, the moderating effect of technological innovation implies that investments in ICT research, digital skills development and ICT service exports should complement digital infrastructure initiatives to maximise productivity gains. These policy measures would contribute to improving industrial competitiveness and supporting Nigeria's digital economy agenda.

5.3.3 Limitations of the Study

Despite its contributions, this study is subject to certain limitations. First, industrial productivity is proxied by GDP growth rate, which may not fully capture sector-specific industrial performance. Second, the analysis focuses exclusively on Nigeria, thereby limiting the generalizability of the findings to other developing economies. Third, the study employs aggregate macroeconomic indicators that may not adequately reflect firm-level digital adoption and innovation activities. Finally, the ARDL methodology identifies long-run and short-run relationships but does not fully account for possible structural breaks or nonlinear relationships that may exist over the study period.

5.4 Directions for Future Research

Future studies may extend the present research in several ways. First, researchers should consider using alternative measures of industrial productivity, such as manufacturing value added, industrial output or total factor productivity, to provide a more direct assessment of industrial performance. Second, comparative studies involving multiple African countries could improve the external validity of the findings and identify regional differences in digital transformation. Third, future research may employ nonlinear or advanced panel estimation techniques to examine whether the relationship between digital connectivity and industrial productivity changes across different stages of economic development. Finally, future studies may incorporate additional institutional and technological variables, including digital skills, research and development expenditure, artificial intelligence adoption and digital governance indicators, to further explain the mechanisms through which digital connectivity influences industrial productivity.

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