Available online at www.koozakar.com/journals/ajspim

African Journal of Science Policy and Innovation Management

Harnessing Science Technology and Innovation Indicators for Enhancing Innovation and Digital Transformation for Improved Policies in Nigeria

R. C. Wakawa, U. Abdulhamid*, A. M. Ademola-Ajibade, A.G. Saadatu, Kazeem Abubakar, V. A. Thompson-Adewole, I. A.John, and B. Adewumi
National Centre for Technology Management (NACETEM), Abuja, Nigeria

*Corresponding author
Email: hazemidoo@gmail.com

Article information

https://doi.org/10.69798/97811025

ISSN (Online): 3066-3660
Copyright ©: 2026 The Author(s).

This is an open-access article distributed under the terms of the Creative Commons Attribution4.0 International (CC-BY-4.0) License, which permits the user to copy, distribute, and transmit the work provided that the original authors and source are credited.

Published by Koozakar LLC. Atlanta GA 30350, United States

A Journal of the African Institute for Science Policy and Innovation, AISPI, Obafemi Awolowo University, Ile-Ife.

Edited by: Prof. Olawale Adejuwon

ABSTRACT

This study explores the strategic use of Science, Technology, and Innovation (STI) indicators to enhance innovation and digital transformation for improved policymaking in Nigeria. It identifies and analyzes key STI indicators that drive technological advancement and digital activities, evaluates current trends and gaps, and assesses their influence on Nigeria's innovation ecosystem. Utilizing linear trend extrapolation, the study finds a statistically robust upward trend in employment in services and intellectual property charges through 2030, alongside a concerning upward trend in unemployment, while high-tech exports, ICT service exports, and medium- and high-tech exports show only weak historical trends (R^2 below 0.10) that warrant cautious interpretation. A SWOT analysis highlights the strengths, weaknesses, opportunities, and threats shaping the STI landscape, offering strategic insights for policy planning. Correlation analysis of secondary data underscores high-tech exports, ICT service exports, and intellectual property charges as pivotal indicators, given the strength of their association with innovation-driven sectors, interpreted with due caution given the limited number of annual observations. The study recommends increased investment in ICT services and high-tech industries, the formulation of robust intellectual property policies, the expansion of innovation hubs and incubation centers, and the promotion of stronger collaboration among government, academia, and industry to foster a more resilient and innovation-oriented economy. Policy Implications: These findings call for stabilizing high-technology export capacity, embedding STI indicator monitoring within the institutional mechanisms of Nigeria's National Digital Economy Policy (2020–2030), and directing investment toward the intellectual property and ICT-export systems identified here as pivotal levers for innovation-led growth.

Keywords: Innovation, Digital Transformation, STI Indicators, Research & Development, and Policy-makers

INTRODUCTION

This paper examines the potential of harnessing Science, Technology, and Innovation (STI) indicators to enhance innovation and digital transformation policies in Nigeria. It specifically focuses on identifying key STI indicators, evaluating prevailing trends, and proposing strategic interventions to improve policy design and implementation. In the 21st century, STI policy has emerged as a critical driver of economic growth and sustainable development. As nations strive to build competitive knowledge-based economies, the role of STI in enabling digital transformation and technological advancement becomes increasingly pivotal. With a dynamic and youthful population, Nigeria is well-positioned to leverage STI as a catalyst for addressing multifaceted socio-economic challenges such as food insecurity, poverty, income inequality, health disparities, and overall well-being (World Bank, 2021). As one of Africa's largest economies (World Bank, 2024), Nigeria has demonstrated significant potential in the technology and innovation landscape. The rise of technology hubs, a burgeoning start-up ecosystem, and expanded internet penetration highlight a growing digital economy. However, despite these promising developments, Nigeria continues to underperform in global innovation benchmarks. According to the Global Innovation Index (GII) (2025), Nigeria ranked 105th out of 139 economies, underscoring the need for more effective strategies to strengthen the national innovation system. STI indicators, including metrics such as research and development (R&D) expenditure, number of researchers, patent filings, innovation outputs, and ICT service exports, are instrumental in assessing a nation's innovation capacity (OECD, 2015). These indicators offer valuable insights into the strengths and limitations of national innovation systems and provide policymakers with evidence to formulate targeted, data-driven interventions. In Nigeria, however, the underutilization and fragmentation of STI indicators have limited their impact on effective policy formulation and implementation.

Nigeria holds a pivotal position in Africa's socio-economic development landscape. It remains one of the continent's largest economies by Gross Domestic Product (GDP), although naira devaluation since 2023 has seen it overtaken by South Africa and Egypt in nominal dollar terms, driven by sectors such as oil and gas, telecommunications, financial services, and a rapidly expanding digital economy (World Bank, 2024; National Bureau of Statistics, 2023). Although historically dependent on crude oil exports, recent efforts have aimed at diversifying the economy through investments in non-oil sectors such as agriculture, ICT, manufacturing, and renewable energy (International Monetary Fund, 2021). These developments align with the broader vision of leveraging science, technology, and innovation (STI) to transition into a knowledge-based economy (National Digital Economy Policy and Strategy, 2020–2030).

Socio-culturally, Nigeria is characterized by remarkable ethnic and linguistic diversity, with over 250 ethnic groups and more than 500 indigenous languages (Pew Research Centre, 2018). The three dominant groups, Hausa-Fulani in the North, Yoruba in the Southwest, and Igbo in the Southeast, form the country's major political and economic blocs. This cultural heterogeneity influences patterns of innovation, especially regarding access to research infrastructure, quality education, and digital services, which vary significantly across geopolitical zones (UNDP, 2020). These regional disparities underscore the need for decentralized STI policies that account for local context.

Within the framework of its National Innovation System (NIS), Nigeria demonstrates both potential and structural limitations. The NIS, defined as the set of institutions and interactions that govern the production, diffusion, and application of innovation, remains fragmented and underdeveloped (Lundvall, 1992; Siyanbola *et al.*, 2016). Weak linkages among key actors such as universities, research institutions, industry, and government have hindered collaborative innovation, limiting the scalability of local technologies and innovations (Oyeyinka, 2012). While cities such as Lagos, Abuja, and Port Harcourt have emerged as innovation clusters, northern regions, particularly the North-East and North-West, suffer from weak innovation infrastructure, lower literacy rates, and insecurity (National Planning Commission, 2021).

Moreover, Nigeria's demographic structure, where over 60% of the population is under the age of 25,

offers a unique opportunity for STI-driven transformation if adequately harnessed (National Population Commission, 2020). This youthful population, increasingly adept at digital tools and entrepreneurship, has spurred the growth of emerging sectors such as fintech, ed-tech, agritech, and health tech (African Union Commission, 2020). However, realizing the demographic dividend requires deliberate policies that invest in digital literacy, STEM education, and entrepreneurial development (UNESCO, 2021).

In summary, Nigeria's socio-economic context, marked by rapid urbanization, regional inequality, youthful demography, and evolving institutional frameworks, makes it an important case for examining the use of STI indicators in fostering innovation and digital transformation. A nuanced understanding of the country's innovation landscape is essential for designing inclusive, context-sensitive, and forward-looking policies that can stimulate sustainable development across all regions.

Siyanbola *et al.* (2016) emphasize that the attainment of development goals requires a rigorous policy process grounded in scientific evidence derived from relevant and reliable data. Unfortunately, in many developing countries, including Nigeria, there remains a significant gap between development needs and policy responses, often due to the absence or unreliability of STI-related data.

The global STI landscape is evolving rapidly, driven by digital technologies and the growing imperative to leverage innovation for economic competitiveness and social inclusion (Freeman & Soete, 2009). In this context, developing robust STI indicators has become essential for measuring progress, diagnosing systemic challenges, and guiding transformative policy actions (Improving Measures of Science, Technology, and Innovation, 2012). For Nigeria, a developing country with a complex and diverse socio-economic profile, the ability to harness STI indicators is fundamental to driving inclusive growth and achieving national development goals (Amukowa & Ayuya, 2013).

Moreover, building absorptive capacity and strengthening the national innovation ecosystem are critical for effective technology transfer and sustainable development (Ajibo *et al.*, 2019). Against this backdrop, this study seeks to explore the role of STI indicators in driving innovation and digital transformation, thereby supporting evidence-based policy formulation and implementation in Nigeria. The research highlights how strategic application of STI data can enhance Nigeria's innovation capabilities, improve competitiveness, and address socio-economic challenges.

While Siyanbola *et al.* (2016) and subsequent National Centre for Technology Management (NACETEM) reviews have established the general case for STI-indicator-based policymaking in Nigeria, they stop short of an integrated empirical assessment of how specific indicators move together and where they are headed. This study extends that literature by combining trend and SWOT analysis, correlation analysis, and linear trend extrapolation within a single framework applied to nine purposively selected STI indicators, an integration that, to the authors' knowledge, has not previously been undertaken for Nigeria's STI system. This combination is intended to move beyond describing Nigeria's innovation performance toward identifying which indicators are most strongly interrelated and how they are likely to evolve, offering a more actionable evidence base for policy design than prior single-method assessments.

Despite the widely acknowledged role of Science, Technology and Innovation (STI) as a critical driver of socio-economic transformation, Nigeria has yet to fully leverage STI indicators to inform and shape transformative innovation policies. Persistent structural challenges, including inadequate investment in research and development (R&D), weak infrastructure, limited availability of skilled human capital, and an ecosystem that often constrains rather than fosters technological entrepreneurship, continue to undermine national innovation performance. These systemic weaknesses contribute to entrenched poverty, food insecurity, poor health outcomes, substandard education, and underwhelming technological progress.

In addition, existing STI indicators and policy frameworks are often misaligned with Nigeria's specific development realities. The absence of integration and coordination among data-generating institutions has resulted in fragmented

evidence bases, inefficiencies in planning, and weak policy execution. As a result, technological advancement has been slow, limiting the country's global competitiveness and hampering its ability to address critical development challenges, including youth unemployment, economic diversification, and digital inclusion.

Addressing these barriers requires a more strategic, evidence-based, and context-sensitive approach to STI policymaking. Central to this is the identification and operationalization of key STI indicators that can serve as reliable inputs for the formulation of responsive innovation and digital transformation policies. Achieving this ambition will necessitate stronger investment in STI infrastructure, the establishment of enabling environments that nurture creativity and innovation, and enhanced coordination among government, academia, and industry stakeholders.

This study seeks to fill this gap by responding to the following research questions:

a. Which STI indicators have the greatest potential to drive innovation and digital transformation in Nigeria?

b. What are the correlations among different STI indicators, and how do they influence innovation and digital transformation outcomes?

c. What is the current state of STI indicators in Nigeria, including their strengths and weaknesses?

d. What are the projected trends in STI indicators in Nigeria from 2024 to 2030?

The overarching aim of this study therefore, is to examine how STI indicators can be harnessed to strengthen innovation and digital transformation for more effective policymaking in Nigeria. The specific objectives are to

a. identify the STI indicators with the greatest potential to catalyze innovation and digital transformation in Nigeria;

b. analyze the interrelationships and correlations among key STI indicators;

c. assess the current state of STI indicators in Nigeria, highlighting existing strengths and weaknesses; and

d. forecast the likely trends of STI indicators from 2024 to 2030 using historical data.

This study focuses on examining the role of Science, Technology and Innovation (STI) indicators in strengthening innovation and digital transformation policy frameworks in Nigeria. The analysis covers data spanning the 2007 to 2019, combining both historical and forward-looking perspectives. In addition, the study projects the trajectory of selected STI indicators up to the year 2030, employing statistical techniques such as trend analysis, correlation analysis, and linear trend extrapolation to guide future policy direction. This mixed-methods approach ensures that both past performance and anticipated future dynamics are considered in evaluating Nigeria's innovation system.

Although the study draws on secondary data from multiple national and international sources to enhance analytical depth and reliability, it is geographically limited to the Nigerian context. Given Nigeria's diverse economic structures, cultural variations, and institutional differences, the findings may not be uniformly applicable across all regions of the country. Moreover, the availability and quality of STI-related data in Nigeria remain uneven, which may affect the comprehensiveness of the analysis. To address this, the study employs purposive sampling and data triangulation, incorporating datasets from reputable global sources such as the World Bank, UNESCO Institute for Statistics, and the World Intellectual Property Organization (WIPO), alongside national sources, to ensure the credibility and relevance of findings. Nevertheless, readers should interpret results within the context of existing data limitations and national specificities.

This study is organized into five sections. Section one introduces the background, problem statement, research questions, and scope. Section two reviews the conceptual and theoretical literature on STI indicators and situates the study within Nigeria's STI landscape. Section three details the data sources and analytical techniques, including correlation analysis, SWOT analysis, and linear trend extrapolation. Section four presents and discusses the results, interpreting their implications for innovation and digital transformation. Section five concludes with a

summary of key insights and evidence-based policy recommendations.

LITERATURE REVIEW

This section critically explores how Science, Technology, and Innovation (STI) indicators can be leveraged to foster innovation and digital transformation, with a specific focus on the Nigerian context. It situates the discussion within the broader body of literature on STI frameworks, innovation ecosystems, and the role of digital transformation in national development. The review also considers Nigeria's current innovation landscape, STI indicators, and regional disparities that influence policy outcomes.

STI Indicators and Innovation Ecosystems

The effective application of STI indicators plays a pivotal role in strengthening technological capacity by providing a robust framework for policy formulation, strategic resource allocation, and performance monitoring. These indicators serve as essential tools for measuring inputs (such as R&D investment), outputs (like patents and publications), and impacts (including tech start-up growth and high-tech exports) within innovation systems. Well-structured STI frameworks are widely associated in the innovation-systems literature with stronger innovation output, as national systems that align policy, institutions, and indicators tend to generate more coherent and cumulative innovation performance over time (Lundvall, 1992; Freeman & Soete, 2009).

Government policy remains one of the most influential enablers of national innovation performance. Strategic investments in research and development infrastructure, intellectual property rights enforcement, and innovation funding schemes are critical to fostering a vibrant entrepreneurial ecosystem. Government R&D investment and supportive STI funding schemes are consistently identified in this literature as catalytic enablers of patenting activity and new business formation, underscoring the role of policy-backed STI investment in spurring innovation-led development (Lundvall, 1992).

In addition, the Triple Helix Model, which emphasizes collaboration between academia, industry, and government, has been widely recognized as a driver of innovation and knowledge commercialization. Firms that engage in structured university–industry partnerships are generally found to exhibit stronger product-innovation performance than those relying solely on in-house R&D, underscoring the importance of institutional synergy in shaping successful innovation outcomes (Etzkowitz & Leydesdorff, 2000; Freeman & Soete, 2009).

Theoretically, this study is anchored in the National Innovation Systems (NIS) framework, which conceptualizes innovation as an outcome of interaction among firms, government, and knowledge institutions rather than a linear product of R&D spending alone (Lundvall, 1992; Freeman, 1995). Complementing this, the Triple Helix model (Etzkowitz & Leydesdorff, 2000) frames university–industry–government collaboration as a central mechanism through which STI indicators such as intellectual property charges and high-tech exports translate into digital transformation outcomes. Together, these frameworks motivate the selection of the nine indicators examined in this study: each is treated as a proxy for a specific node or linkage within Nigeria's national innovation system, ranging from knowledge commercialization (intellectual property charges) to industrial upgrading (high- and medium-tech exports) to labour-market absorption (employment and unemployment indicators).

Overview of STI Indicators, Innovation, and Digital Transformation in Nigeria

Economic Synopsis

Nigeria possesses a diverse and rapidly evolving economy, underpinned by strong sectors in finance, communications, agriculture, and technology (World Bank, 2021). Historically, the Nigerian economy has been heavily reliant on oil exports, which have served as the principal source of government revenue (Central Bank of Nigeria, 2020). However, increasing volatility in global oil markets and the need for economic resilience have driven national efforts toward diversification. As a result, sectors such as services, agriculture, and ICT have gained renewed policy attention (National Bureau of Statistics, 2020).

Innovation and Digital Transformation Landscape

Nigeria's digital transformation has been driven largely by innovation within the tech sector, bolstered by mobile connectivity, digital platforms, and a surge in entrepreneurial activities.

Urban centers like Lagos, Abuja, and Port Harcourt have emerged as innovation hotspots, supported by government-backed initiatives, start-up accelerators, and technology hubs (African Union Commission, 2020). For instance, policies administered by the National Information Technology Development Agency (NITDA) have included the establishment of technology incubation centres and funding schemes to support early-stage entrepreneurs (NITDA, 2024).

Nigeria's demographic advantage, with one of the youngest populations globally (median age approximately 18), offers both a challenge and an opportunity for digital transformation (National Population Commission, 2019). Young Nigerians are increasingly leveraging digital tools to drive innovation across key sectors such as fintech, ed-tech, agri-tech, and health tech (United Nations Development Programme, 2020). This youthful demographic, when equipped with digital skills, forms a vital foundation for a future-ready innovation workforce.

STI Indicators in Nigeria

The STI indicators utilized to assess innovation performance in Nigeria span a variety of economic, social, and technological dimensions. Key indicators include:

i. Employment in services (% of total employment)

ii. New business density

iii. Total self-employed (% of total employment)

iv. Charges for the use of intellectual property (BoP, current US$)

v. Total unemployment (% of total labour force)

vi. High-technology exports (% of manufactured exports)

vii. ICT service exports (% of service exports, BoP)

viii. Medium and high-tech exports (% of manufactured exports)

ix. Value-added services (% of GDP)

These indicators provide a multidimensional picture of Nigeria's innovation potential and digital economy. They also serve as vital inputs for policymaking, enabling government agencies to monitor progress and refine innovation strategies in alignment with national development goals.

Regional Disparities

While cities like Lagos and Abuja continue to thrive as innovation centers, significant regional disparities persist. Northern Nigeria, in particular, faces higher rates of poverty, lower educational attainment, and reduced access to digital infrastructure (National Bureau of Statistics, 2020). These disparities highlight the uneven distribution of innovation-enabling resources and underscore the importance of spatially inclusive STI policy design. Tailored regional policies are essential to ensure equitable access to innovation opportunities across the country.

Integrating STI Indicators with Innovation and Digital Policy

The reviewed literature emphasizes that countries that effectively utilize STI indicators to inform policy decisions tend to exhibit more resilient and adaptive innovation ecosystems. In the case of Nigeria, aligning STI indicators with innovation and digital transformation efforts can serve as a pathway to address persistent development challenges and enhance global competitiveness. However, this requires strengthening institutional capacity for data collection, coordination, and strategic analysis.

The present study extends this discourse by addressing how STI indicators dynamically interact with Nigeria's socio-economic realities to influence policy outcomes. While the literature supports the utility of STI metrics, it also stresses that meaningful impact depends on the existence of a coordinated multi-stakeholder ecosystem. This includes not only the government but also universities, research institutions, industry players, and international partners. For STI indicators to translate into effective policy, these actors must collaborate around shared objectives, open data platforms, and integrated planning frameworks.

Practical Implications

Strengthening STI indicators for innovation and digital transformation in Nigeria demands a whole-of-society approach. Policymakers must prioritize evidence-based strategies, research institutions should build their capacity to generate

and interpret STI data, and the private sector must remain an active partner in technological advancement. Furthermore, effective coordination and communication channels among stakeholders are essential to align efforts and mobilize resources efficiently. Such an integrated approach will not only enhance the impact of STI investments but also create a more inclusive and resilient innovation-driven economy.

METHODOLOGY

Sampling Technique

This study employed a purposive sampling technique to identify and select relevant Science, Technology, and Innovation (STI) indicators critical for evaluating innovation and digital transformation in Nigeria. Purposive sampling is appropriate for studies seeking to analyze specific variables of interest based on expert judgment and relevance to the research objectives. As this research aimed to provide a focused assessment of STI contributions to innovation policy, indicators were selected based on their theoretical relevance, empirical validity, and availability across consistent time series. This approach is well-supported in innovation systems research, especially when the research problem involves multiple policy-oriented constructs (OECD, 2015).

Type of Data and Selection of Indicators

The data used in this study comprised quantitative secondary data. The STI indicators selected represent key dimensions of innovation capacity, economic performance, and digital transformation. These indicators were chosen in alignment with internationally recognized STI frameworks, such as those used by the OECD, UNESCO Institute for Statistics, and the Global Innovation Index. The selected indicators include:

i. Employment in Services (% of Total Employment): A proxy for the knowledge economy's development and the expanding role of ICT-driven services.

ii. New Business Density (new registrations per 1,000 people aged 15–64): An entrepreneurship metric reflecting innovation dynamism and economic vibrancy.

iii. Total Self-Employed (% of Total Employment): Indicates the prevalence of entrepreneurial activity and informal innovation.

iv. Charges for the Use of Intellectual Property (BoP, current US dollars): Captures revenue flows associated with innovation outputs and technology licensing.

v. Total Unemployment (% of Total Labour Force): Provides insight into labour market inefficiencies and human capital underutilization.

vi. High-Technology Exports (% of Manufactured Exports): Reflects the technological sophistication of a country's export portfolio.

vii. ICT Service Exports (% of Service Exports, BoP): Measures Nigeria's participation in the global digital economy.

viii. Medium and High-Tech Exports (% of Manufactured Exports): Indicates industrial upgrading and innovation intensity in manufacturing.

ix. Value-Added Services (% of GDP): Assesses the contribution of service-based innovation to national income.

These indicators offer a multidimensional lens for assessing Nigeria's innovation ecosystem and provide empirical grounding for policy discussions.

Data Collection

Data for the study spanned the period 2007 to 2019 to ensure sufficient temporal coverage and allow robust analysis of trends and structural shifts. Data were gathered from reputable international and national databases, including the World Bank, International Labour Organization (ILO), UNESCO Institute for Statistics, and Nigeria's National Bureau of Statistics (NBS).

The chosen time frame ensures that the dataset captures periods of significant economic and policy changes, such as the implementation of Nigeria's National Digital Economy Policy (2020–2030) and the growing influence of digital entrepreneurship. Additionally, the data consistency across years supports reliable longitudinal analysis, which is critical for evaluating the long-term impact of STI policy interventions.

Forecasting of STI Indicator Data

In order to extend the utility of the dataset and assess future implications, the study employed

time-series forecasting techniques to project STI indicator values up to 2030. Forecasting serves as an essential policy tool for anticipating future trends, identifying emerging challenges, and formulating proactive strategies in a rapidly evolving innovation landscape.

The linear trend extrapolation approach (ordinary least squares regression on year) was used to forecast the future trajectory of selected indicators. This method fits the straight line that minimizes total squared deviation from the historical annual values and extends it forward; it is transparent and easy to replicate, though it assumes the historical trend continues unchanged (Hyndman & Athanasopoulos, 2018). This forecasting provided a transparent, if methodologically simple, basis for anticipating likely scenarios for Nigeria's STI-driven innovation performance, with the coefficient of determination (R^2) reported for each indicator so that its reliability can be judged directly.

Analytical Techniques: Descriptive Statistics

Descriptive statistics were employed to summarize and interpret the basic features of the STI data set, offering insights into central tendencies (mean, median), variability (standard deviation), and distributional characteristics across time. This preliminary analysis is foundational in time-series studies, helping to reveal structural patterns, detect anomalies, and provide a contextual basis for deeper statistical modelling (Field, 2013). By examining STI indicators from 2007 to 2019, the descriptive statistics facilitated an understanding of historical trends in innovation-related variables such as high-tech exports, ICT service contributions, and intellectual property transactions in Nigeria.

SWOT Analysis

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) framework was adopted to strategically assess Nigeria's STI landscape. SWOT analysis is widely used in innovation policy research for its utility in aligning internal capabilities with external opportunities and threats (Helms & Nixon, 2010). In this study, the SWOT approach helped contextualize Nigeria's current STI status within its broader socio-economic development goals. For instance, the country's youthful demographic and emerging innovation hubs represent strengths and opportunities, whereas limited research infrastructure and policy incoherence were identified as weaknesses and threats. This qualitative technique complements quantitative findings by offering a strategic lens through which stakeholders can interpret data-driven results and formulate responsive STI policies.

Correlation Analysis

To examine the strength and direction of associations among STI indicators and innovation-related outcomes, Pearson correlation analysis was conducted. This statistical method measures the strength and direction of linear association between pairs of variables (Hair *et al.*, 2014). Given the limited number of annual observations available for these indicators, the resulting coefficients are interpreted as indicative of association rather than as confirmed statistical relationships; full results and the accompanying caveats are presented in the Results and Discussion section.

Forecasting Using Linear Trend Extrapolation

The study employed the linear trend extrapolation (ordinary least squares regression) to forecast the trajectories of selected STI indicators through 2030. This is a transparent, widely used baseline forecasting technique, well suited to short annual series where more data-intensive methods such as ARIMA are difficult to estimate reliably (Hyndman & Athanasopoulos, 2018). By fitting linear trends to data on employment, self-employment, intellectual property charges, unemployment, high-tech exports, ICT service exports, medium- and high-tech exports, and services value added, the study generated transparent, replicable projections, while flagging — through the reported R^2 values — which indicators have a historical relationship with time too weak to forecast reliably by this or any trend-based method.

Collectively, these analytical tools allowed for a comprehensive and data-driven understanding of how STI indicators influence innovation and digital transformation within Nigeria's socio-economic context.

RESULTS AND DISCUSSION

The linear-trend-extrapolation-based projections of selected Science, Technology, and Innovation (STI) indicators between 2020 and 2030 provide

forward-looking, if methodologically simple, evidence on Nigeria's innovation and digital transformation trajectory. The results demonstrate consistent, though varied, patterns of growth, decline, and structural transition across indicators that are central to the country's socio-economic development.

Table 1 values are point forecasts from a simple linear trend (ordinary least squares regression of each indicator on year, fitted to the 2007–2019 data). The coefficient of determination (R^2), which indicates how much of the historical variation is explained by a linear time trend, is: Employment in Services 0.96; Self-Employed, Total 0.69; Charges for Intellectual Property 0.72; Unemployment, Total 0.72; Services Value Added 0.25; High-Tech Exports 0.07; ICT Service Exports 0.02; and Medium and High-Tech Exports 0.01. Forecasts for the first five indicators reflect a historically consistent linear trend and are reasonably reliable as a baseline projection; forecasts for the last three, where R^2 is below 0.10, explain almost none of the historical variation and should be treated as illustrative only — for these three indicators in particular, the historical data show large, irregular swings driven by specific episodes rather than a steady trend, and no linear model can be expected to forecast them reliably.

Table 1: Forecast of the STI indicator from 2020 to 2030 (using linear trend extrapolation)

Indicator Name	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Employment in Services	54.4	55.0	55.7	56.4	57.0	57.7	58.3	59.0	59.7	60.3	61.0
Self-Employed, Total	79.9	79.6	79.2	78.9	78.6	78.2	77.9	77.6	77.2	76.9	76.5
Charges for Intellectual Property	2.8	2.8	2.9	3.0	3.0	3.1	3.2	3.2	3.3	3.3	3.4
Unemployment, Total	8.4	8.8	9.3	9.7	10.2	10.6	11.1	11.5	12.0	12.4	12.9
High-Tech Exports	3.8	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.5	5.7	5.9
ICT Service Exports	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6
Medium and High-Tech Exports	34.1	34.5	34.9	35.3	35.7	36.1	36.5	36.9	37.3	37.7	38.1
Services Value Added	55.6	56.0	56.5	56.9	57.4	57.8	58.3	58.7	59.2	59.6	60.1

Source: NACETEM data Forecast, 2024

Interpretation and Policy Relevance

The linear trend extrapolation shows a strong, statistically credible upward trend in employment in services (R^2 = 0.96), projected to rise from 54.4% in 2020 to 61.0% by 2030, alongside a comparably credible downward trend in self-employment (R^2 = 0.69), from 79.9% to 76.5%, consistent with a gradual shift toward formal service-sector employment. High-tech exports, ICT service exports, and medium- and high-tech exports, by contrast, show only weak historical relationships with time (R^2 of 0.07, 0.02, and 0.01 respectively), meaning a linear trend explains almost none of their year-to-year variation. Their extrapolated values, high-tech exports rising from 3.8% in 2020 to 5.9% by 2030, ICT service exports from 5.6% to 7.6%, and medium- and high-tech exports from 34.1% to 38.1%, should therefore be treated as illustrative rather than reliable predictions; historically these three indicators have moved in large, irregular swings (high-tech exports spiked to 12% in 2015, ICT service exports to 21% in 2012) driven by episodic events rather than a steady underlying trend.

Charges for intellectual property show a more modest but still statistically credible upward trend (R^2 = 0.72), rising from approximately 2.8% in 2020 to 3.4% by 2030. This signals gradual improvement in the commercialization of research outputs, though the pace is slow. Policy emphasis on strengthening intellectual property protection, improving technology transfer, and incentivizing universities and research institutes to engage in commercialization remains important (WIPO, 2022).

Unlike employment and self-employment, unemployment is projected to continue rising rather than improving, from 8.4% in 2020 to 12.9% by 2030 (R^2 = 0.72), extending the upward trajectory already visible in the historical data (2007–2019) rather than reversing it. This is a substantially less optimistic picture than a simple continuation of recent-year stabilization might

suggest, and it underscores the scale of labour-market intervention needed alongside Nigeria's digital and services growth; addressing this gap will require parallel investments in workforce skills, digital entrepreneurship, and labour-intensive innovation sectors (National Bureau of Statistics, 2022).

Taken together, the projections point to genuine, if modest, structural strengthening in services employment and intellectual property commercialization, set against a persistently rising unemployment trend that existing policy has not yet reversed, and a set of high-technology trade indicators too volatile for reliable trend-based forecasting. Strengthening the underlying industrial base envisioned in the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) may do more to move high-tech and medium-tech exports than extrapolating their noisy historical trend (African Union, 2014).

Policy Relevance and Strategic Implications

The projections derived from the linear trend extrapolation offer actionable insights for Nigeria's STI and digital transformation policy agenda. Sustaining positive trajectories and reversing the rising unemployment trend will require coordinated interventions to:

a. Strengthen R&D and STI infrastructure in universities, research institutes, and innovation hubs;

b. Expand digital literacy and inclusion programs to ensure equitable participation in the innovation economy;

c. Enhance intellectual property systems and promote commercialization of research outputs;

d. Support high-tech start-ups and SMEs through public–private partnerships and financing mechanisms;

e. Develop regional innovation ecosystems to reduce disparities and integrate local economies into global value chains.

From the foregoing, the trend extrapolation forecasts underscore both opportunities and challenges. The credible upward trends in services employment and intellectual property commercialization signal gradual strengthening of Nigeria's innovation-relevant institutions. However, the continued rise in unemployment and the high statistical uncertainty surrounding high-tech and ICT export trends highlight areas needing urgent policy attention and further investigation. Anchoring interventions in empirical evidence, as demonstrated in this study, is vital for aligning Nigeria's STI priorities with Vision 2050 and the Sustainable Development Goals (SDGs).

The Current State of STI Indicators in Nigeria: A SWOT Analysis

To evaluate the capacity of Nigeria's Science, Technology, and Innovation (STI) ecosystem to drive innovation and digital transformation, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted using longitudinal STI indicator data from 2007 to 2019. This analytical framework provides a strategic perspective for policymakers, researchers, and stakeholders to identify leverage points as well as systemic challenges within Nigeria's innovation landscape.

Strengths

a. Expansion of the Services Sector: A key strength of Nigeria's STI ecosystem is the sustained expansion of the services sector. The share of total employment in services rose from 45% in 2007 to 53% in 2019, reflecting a gradual structural transition toward a more knowledge-intensive, service-driven economy. This development highlights improvements in labour productivity, urbanization, and economic diversification—factors that underpin digital transformation (World Bank, 2020).

b. Contribution of Services to GDP: Value-added services have consistently supported national economic growth, contributing as much as 59.8% to GDP in 2016 and stabilizing around 50% in recent years. This resilience is most evident in financial services, information technology, and telecommunications—sectors that are central to Nigeria's digital economy (NBS, 2022; African Union Commission, 2020). The strength of the service sector positions it as a driver of innovation adoption and digital transformation across industries.

Weaknesses

a. Rising Unemployment: Nigeria's unemployment rate increased from 3.8% in 2007 to 8.5% in 2019, reflecting structural weaknesses

in labour market absorption. This persistent rise underscores the inability of the economy to generate sufficient employment in productive, innovation-driven sectors (ILO, 2022). Moreover, it points to a misalignment between workforce skills and the demands of the evolving innovation ecosystem (UNDP, 2020).

b. Low and Volatile High-Tech Exports: High-tech exports, while peaking at 12% in 2015, fell drastically to just 1% by 2019. This volatility demonstrates Nigeria's weak capacity in high-technology production and its limited integration into global technology value chains. The absence of consistent investment in R&D and industrial policy to strengthen technological competitiveness further constrains the country's innovation performance (UNESCO, 2015; NACETEM, 2024).

Opportunities

a. Stable Entrepreneurial Base: New business density has remained relatively stable, averaging 0.8 new registrations per 1,000 working-age individuals. While modest, this indicator reflects a resilient entrepreneurial foundation upon which stronger start-up ecosystems can be developed. With enabling regulatory reforms and expanded digital infrastructure, Nigeria could leverage this entrepreneurial momentum for innovation-led growth (World Bank, 2020).

b. Growth of ICT Service Exports**:** ICT service exports represent another promising opportunity, having peaked at 21% of total service exports in 2012 and maintained a stable 4–5% contribution thereafter. This trajectory affirms Nigeria's rising role as a regional ICT hub, particularly in fintech, digital media, and mobile applications (Federal Ministry of Communications and Digital Economy, 2020). With growing global demand for digital services, scaling ICT exports through targeted investment and capacity development could significantly enhance Nigeria's competitive advantage.

Threats

a. Declining Self-Employment**:** The share of self-employed individuals fell from 85.3% in 2007 to 79.9% in 2019. While part of this decline may reflect transitions into formal sector jobs, it may also signal declining opportunities in informal entrepreneurship—particularly in rural and underserved regions (NBS, 2020). Left unaddressed, this downward trend could weaken grassroots innovation and limit the adaptive capacity of the informal economy.

b. Economic Instability and Policy Uncertainty Volatility in indicators such as unemployment, high-tech exports, and self-employment points to broader macroeconomic instability and policy unpredictability. These conditions erode investor confidence, constrain long-term R&D investment, and slow innovation-led development. Weak coordination and inconsistent execution of STI policies exacerbate these risks, undermining the effectiveness of Nigeria's innovation system (UNESCO, 2015)

Overall Strategic Implications

The SWOT analysis underscores the dual nature of Nigeria's STI environment, possessing pockets of strength, particularly in services and ICT, while also grappling with persistent structural and institutional weaknesses. Strategic intervention is required to stabilize the innovation ecosystem, improve the coherence of STI policies, and enhance institutional coordination. By bolstering high-tech production, improving labor market responsiveness, and fostering an inclusive digital economy, Nigeria can reposition its STI landscape to better align with national development priorities and the UN Sustainable Development Goals (SDGs). The consistent monitoring and evaluation of STI indicators will be essential for adaptive policymaking and evidence-based planning (African Union, 2014; Siyanbola *et al.*, 2016).

Monitoring the Trend of STI Indicators (2007–2019)

A trend analysis of STI indicators (Figure 1) highlights important developments, particularly the notable rise in high-technology exports from 0% in 2007 to 12% in 2015, followed by a sharp decline to 1% in 2019. This brief surge signals potential for competitive advantage in niche tech sectors, likely driven by government programs and private sector innovation hubs during that period. However, the decline underscores the fragility of Nigeria's innovation output and the need for sustainable industrial and innovation policy support (NACETEM, 2024; UNESCO, 2015).

Figure 2 illustrates a significant upward trend in ICT service exports, increasing from 1.9% in 2007

to a peak of 21% in 2012, before stabilizing at approximately 4-5% between 2016 and 2019. This trajectory reflects a growing demand for ICT-related services and suggests a developing competitive edge for Nigeria in the digital services sector. The peak in 2012 may be attributed to increased

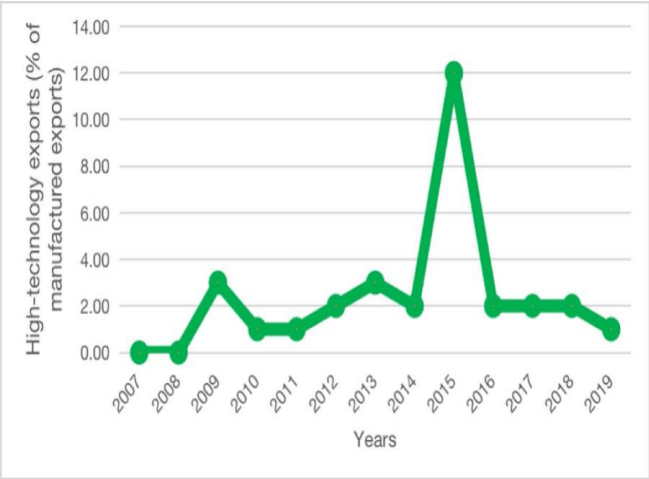


Figure 1: High Technology Exports

investment in telecommunications infrastructure and the emergence of ICT-focused enterprises, while the subsequent stabilization indicates a maturing market with sustained relevance in the national export profile.

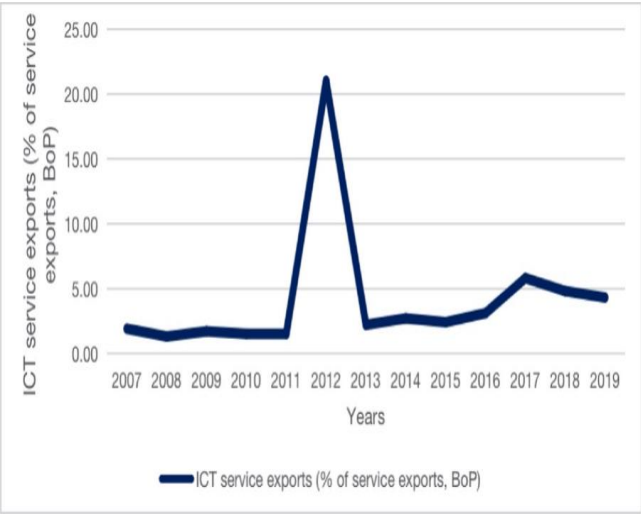


Figure 2: ICT Services, Export

Furthermore, the contribution of services to Nigeria's GDP demonstrated notable resilience, maintaining an average of 50% over the years and peaking at 59.8% in 2016. This trend reflects the robustness and stability of the country's service sector, which continues to serve as a critical driver of economic activity. These strengths align with the broader literature emphasizing the pivotal role of ICT and high-technology industries in accelerating economic growth in developing economies (Freeman & Soete, 2009).

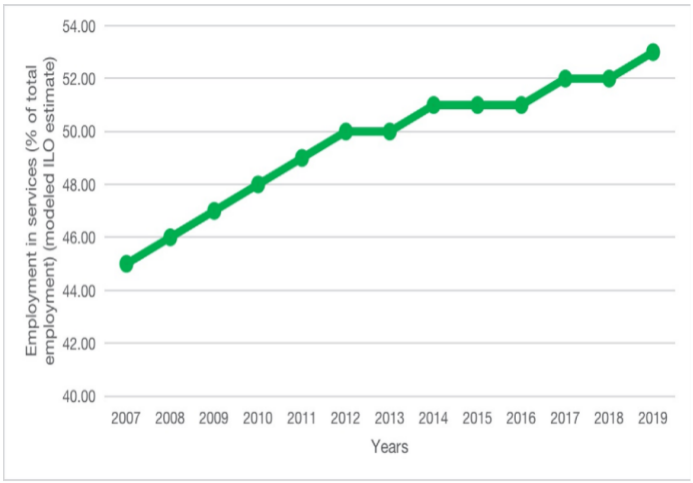


Figure 3: Employment in Services

Employment in the services sector and the rate of self-employment have shown a steady upward trend since 2021, corresponding with a gradual decline in the overall unemployment rate during the same period. This pattern suggests improving labour market conditions and a shift toward more diversified and entrepreneurial economic activities.

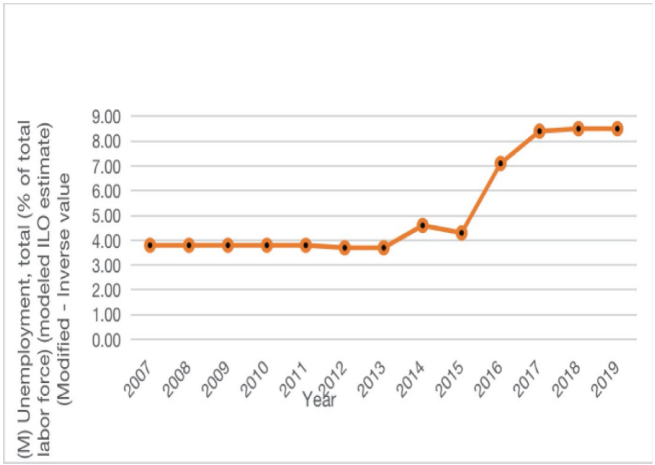


Figure 4: Total Unemployment

The results also highlight significant labour market challenges (Figure 4). Beginning at a relatively low unemployment rate of 3.8% in 2007, the figure rose sharply to 8.5% between 2018 and 2019, indicating a deteriorating

employment landscape and growing difficulty in absorbing the expanding workforce into productive sectors.

A consistently high self-employment rate, exceeding 80%, reflects a significant reliance on informal and often unpaid work, underscoring the limited availability of formal employment opportunities within the Nigerian labour market (Figure 5).

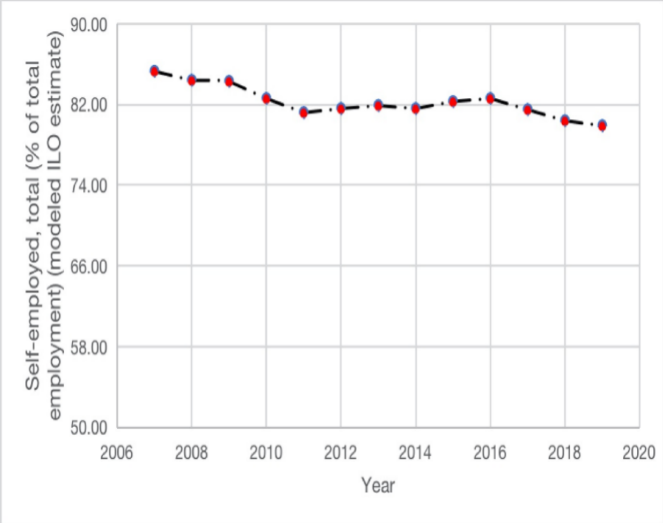


Figure 5: Total Self-Employment

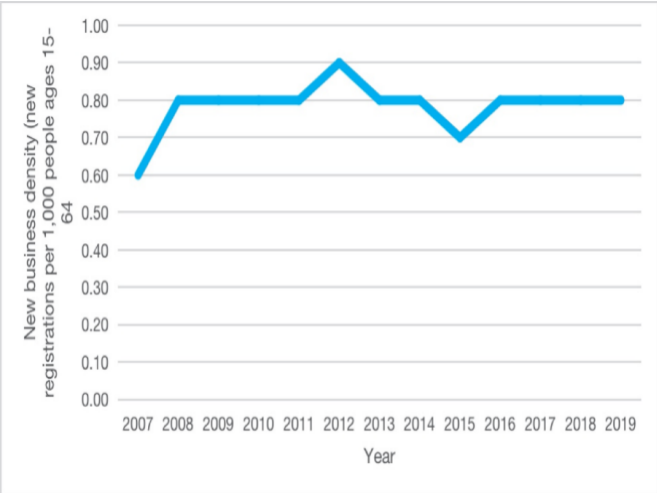


Figure 6: New Business Density

The trend indicates that, with minimal fluctuations, new business density remained relatively constant at 0.8 between 2008 and 2012. This stability suggests a limited pace of entrepreneurial expansion during the period, reflecting potential structural or regulatory constraints on new business formation.

Figure 7 illustrates that the relatively low and stagnant fees associated with the use of intellectual property suggest Nigeria is not fully capitalizing on the commercialization of intellectual assets. This underperformance underscores the need for targeted policy interventions aimed at strengthening the intellectual property (IP) ecosystem, promoting formal employment opportunities, and fostering a more robust entrepreneurial climate.

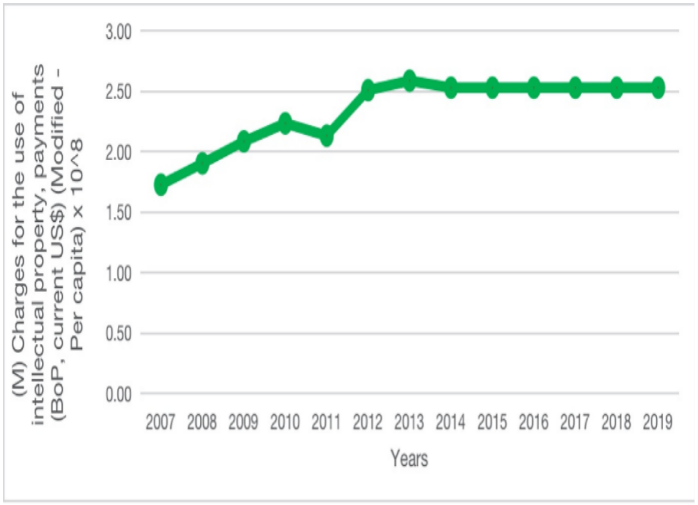


Figure 7: Charges for Intellectual Property

Enhancing IP commercialization could unlock significant value in the innovation system by incentivizing creativity and protecting proprietary technologies. This constraint is consistent with the broader literature identifying weak intellectual property management as a limitation on STI performance in developing countries (Siyanbola *et al.*, 2016).

Correlation Analysis: Exploring the Relationship between STI Indicators and Innovation and Digital Transformation in Nigeria

To gain a deeper understanding of how Science, Technology, and Innovation (STI) indicators interact to influence Nigeria's innovation capacity and digital transformation agenda, a correlation analysis was conducted. This statistical technique provides insights into the strength and direction of linear relationships between key STI metrics, thereby guiding evidence-based policymaking.

Interpretation and Contextual Implications

Because this analysis draws on approximately 13 to 17 annual observations per indicator (reflecting differences in data availability across sources), the

correlation coefficients reported above are subject to considerable sampling variability, and several would not meet conventional statistical significance thresholds at these sample sizes. Coefficients are therefore interpreted here as indicative of the strength and direction of association rather than as confirmed statistical relationships, and coefficients below approximately |0.5| should be treated with particular caution.

Table 2: Relationship between the STI Indicators

	ES	NBD	SE	CIP	U	HTE	ICT	TE	SVA
Employment in Services	1								
New business Density	0.4036	1							
Self-Employed, Total	-0.8982	-0.5167	1						
Charges for Intellectual Property	0.9247	0.4992	-0.7946	1					
Unemployment, Total	0.7262	0.1308	-0.5861	0.5031	1				
High-Tech Exports	0.2988	-0.208	-0.0916	0.394	-0.0913	1			
ICT Service Exports	0.25	0.5336	-0.2889	0.3387	0.0308	-0.0347	1		
Medium and High-Tech Exports	-0.0744	-0.2935	0.1457	-0.2285	0.238	0.1519	-0.2421	1	
Services Value Added	0.4775	-0.1021	-0.1066	0.5539	0.3306	0.5829	-0.0967	-0.1686	1

Source: NACETEM (2023)

All correlations are drawn from a single-country time series and describe how Nigeria's own indicators moved together over the study period; they are not cross-country comparisons and should not be interpreted as evidence of causation. The correlation matrix presented in Table 2 highlights the relationships among several Science, Technology and Innovation (STI) indicators, revealing important insights into how economies evolve through services, entrepreneurship, intellectual property generation, and trade in technology-based goods and services.

One of the most striking findings is the strong positive association between employment in services and charges for intellectual property (0.92). This suggests that, within Nigeria's own economy over the period studied, periods of stronger service-sector employment have tended to coincide with higher intellectual property charges; as a single-country time series, this association should not be read as a cross-country causal claim. In other words, knowledge-intensive services, such as information technology, finance, research and development, and professional services, tend to provide the foundation upon which innovation and intellectual property flourish. This relationship is reinforced by the positive correlation between service employment and services value added (0.48), indicating that as service employment expands, so does the overall contribution of services to the economy. However, the relationship between service employment and unemployment (0.73) complicates this picture. It implies that even in economies where services are expanding, structural unemployment can persist, possibly because service sector jobs may not be sufficiently inclusive or may be concentrated in high-skill areas that leave lower-skilled workers behind.

The role of self-employment appears to stand in sharp contrast to that of formal service sector employment. Self-employment shows strong negative correlations with service employment (-0.90), intellectual property charges (-0.79), and unemployment (-0.59). This pattern suggests that in years when self-employment was more prevalent in Nigeria, service-based, knowledge-driven economic activity tended to be weaker, and the generation of intellectual property is limited. Moreover, the negative link with unemployment indicates that self-employment appears, in Nigeria's case, to act as a coping strategy during periods with fewer formal job opportunities. However, the relatively weak or negative associations between self-employment and ICT or high-tech exports further highlight that self-employment in Nigeria is concentrated in

informal, low-tech, or subsistence activities rather than innovation-driven ventures.

New business density, which measures entrepreneurial activity in terms of the creation of new firms, occupies an interesting position in the matrix. It is positively correlated with ICT service exports (0.53) and intellectual property charges (0.50), indicating that vibrant entrepreneurial ecosystems can foster both innovation and participation in digital and knowledge-based global markets. At the same time, new business density is negatively associated with self-employment (-0.52), which suggests that the creation of formal firms reduces reliance on informal self-employment. Yet, the weakly negative correlation with medium- and high-tech exports (-0.29) implies that while entrepreneurship supports service-driven innovation, it does not necessarily translate into an immediate boost in high-tech manufacturing exports. This points to a duality in entrepreneurial ecosystems, where start-ups and new firms may be oriented more toward services and digital sectors rather than traditional manufacturing industries.

The indicator charges for intellectual property further underscores the centrality of knowledge and services in innovation-driven economies. Apart from its strong ties with service employment, it is also positively associated with new business density (0.50), ICT service exports (0.34), and services value added (0.55). Together, these relationships reveal that intellectual property thrives in economies where services are dynamic, entrepreneurship is active, and ICT is an important export sector. Conversely, its negative association with self-employment (-0.79) reinforces the notion that informal or survivalist forms of work do not contribute meaningfully to the creation or commercialization of intellectual property.

When turning to high-tech exports, the correlations tell a somewhat different story. High-tech exports are positively associated with services value added (0.58) and intellectual property charges (0.39), suggesting that knowledge spillovers from strong service sectors and robust innovation systems can also benefit high-tech manufacturing. However, high-tech exports show relatively weak or negative correlations with new business density and self-employment, which implies that they rely less on new firm creation or informal activities, and more on established industrial capacities and technological infrastructures. Similarly, medium- and high-tech exports show mostly weak relationships with other indicators, with only a slight positive correlation with unemployment (0.24). This may reflect jobless growth in manufacturing exports, where industrial performance does not necessarily translate into broader employment gains.

The case of ICT service exports highlights a service-led innovation pathway. ICT exports are most strongly correlated with new business density (0.53), which demonstrates how entrepreneurial activity can drive the growth of digital and ICT-based industries. ICT services are also positively linked with intellectual property charges (0.34) and service employment (0.25), showing that ICT growth is embedded within broader knowledge-based and service-intensive economies. Interestingly, ICT exports have a weak negative relationship with medium- and high-tech exports (-0.24), suggesting that, over this period, Nigeria's export profile tended to lean toward either ICT services or manufacturing exports rather than both simultaneously.

Finally, services value added emerges as a bridging indicator, linking services, innovation, and high-tech exports. It is positively associated with charges for intellectual property (0.55), high-tech exports (0.58), and employment in services (0.48), confirming that services are not only a driver of domestic value creation but also an enabler of innovation and technological competitiveness. However, its moderate positive relationship with unemployment (0.33) reinforces earlier concerns about the limited inclusiveness of service-led growth, which can leave behind segments of the workforce.

Strategic Insights for Nigeria

Taken together, the correlations in Table 2 suggest that there are two main pathways through which economies align their STI performance:

A service-innovation-ICT pathway, characterized by strong linkages between services, intellectual property, ICT exports, and entrepreneurship. This pathway reflects knowledge-intensive growth and is more associated with innovation-driven economies. A manufacturing-export pathway, reflected in medium- and high-tech exports, which

shows weaker connections with entrepreneurship and intellectual property, and tends to be less inclusive in terms of employment creation.

Meanwhile, self-employment emerges as a structural counterpoint to both pathways, being negatively associated with services, intellectual property, and high-tech exports. This suggests that without supportive policies, high rates of self-employment may trap economies in low-productivity activities, disconnected from innovation-driven growth.

In summary, the table underscores the complexity of STI dynamics: while service-driven innovation and ICT exports are interlinked and contribute to value creation, they do not always translate into broad employment gains. Conversely, manufacturing-based export growth can boost competitiveness but may not rely on entrepreneurship or foster inclusive labor market outcomes. Policymakers therefore face the challenge of balancing service- and manufacturing-led pathways, while also ensuring that self-employment is transformed from survivalist activity into a more productive and innovation-aligned force within the economy.

Such data-driven policy alignment will be vital to achieving Nigeria's digital transformation agenda, consistent with its National Digital Economy Policy and Strategy 2020–2030 and the African Union's Agenda 2063 for inclusive and sustainable growth through STI

CONCLUSION

This study critically examined the role of Science, Technology, and Innovation (STI) indicators in enhancing innovation and driving digital transformation for improved policymaking in Nigeria. By analysing longitudinal data from 2007 to 2019, and forecasting trends to 2030 using linear trend extrapolation (ordinary least squares regression), the study provided empirical insights into the dynamics of Nigeria’s STI landscape. Complementing the trend extrapolation analysis, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and Correlation Analysis were employed to identify the most influential indicators and their relationships with innovation outcomes (UNESCO, 2021).

The study utilized secondary data obtained from credible international and national databases, including the World Bank, ILO, and NACETEM datasets. Findings indicated that certain STI indicators, particularly high-technology exports, ICT service exports, and charges for the use of intellectual property, play a pivotal role in driving innovation and digital transformation. These indicators were shown to have notable positive correlations with Nigeria's innovation outputs and service sector growth (World Bank, 2021; NACETEM, 2024).

The study provides a comprehensive evaluation of Nigeria’s STI indicators and their capacity to catalyse innovation and digital transformation. It highlights the strategic significance of enhancing high-tech industries, improving ICT services, and strengthening intellectual property rights frameworks (WIPO, 2022). Employment in services and the expansion of value-added activities were also identified as important contributors to innovation-led economic development.

Contribution to Knowledge

This study contributes to the STI policy literature in Nigeria by combining trend and SWOT analysis, correlation analysis, and linear trend extrapolation within a single framework applied to nine purposively selected STI indicators, an integration not previously undertaken for Nigeria’s STI system. Empirically, it demonstrates that services employment and intellectual property commercialization are on a statistically credible growth trajectory, while high-technology exports, ICT service exports, and medium- and high-tech exports are too volatile for reliable trend-based forecasting, and that unemployment is on a rising rather than improving trajectory. For policymakers and institutions such as NACETEM, these findings provide an evidence base for prioritizing labour-market intervention and export diversification over continued reliance on noisy trade indicators. For researchers, the combined trend–correlation–SWOT framework offers a replicable, low-data approach for tracking STI performance in other developing-country contexts.

Policy Implications

Beyond the general conclusions above, the findings of this study carry direct implications for the policy mechanisms through which Nigeria’s

STI institutions operate. The recommendations below are organized around the specific indicators found to be weakest or most volatile in the analysis, and are addressed to the policy and regulatory mechanisms, including budgetary allocation processes, intellectual property administration, innovation-hub governance, and inter-institutional coordination frameworks, best placed to act on them.

By identifying areas of strength, such as a growing ICT export base, and pinpointing weaknesses, such as low high-tech export consistency and rising unemployment, the study contributes to a clearer understanding of Nigeria's innovation ecosystem. These insights are crucial for refining STI policy frameworks, strengthening institutional capacity, and creating a more inclusive and resilient innovation environment. Ultimately, the findings reinforce the need for evidence-based policy measures that support a robust digital economy and foster sustainable development across the country. Based on the key findings of this study, the following policy actions are recommended to enhance Nigeria's STI indicators and foster a thriving innovation and digital transformation ecosystem:

a. Increase Investment in ICT and High-Tech Industries: The government should prioritise targeted investments in ICT infrastructure and high-technology manufacturing sectors. This could include tax incentives, startup grants, concessional loans, and import duty waivers for digital equipment and R&D inputs. (African Union Commission, 2020). Such incentives would promote industry growth and stimulate the development of digital products and services that can compete globally.

b. Strengthen Intellectual Property (IP) Frameworks: Nigeria must implement robust legal and institutional frameworks that protect intellectual property and encourage innovation. Policies should streamline the patenting process, provide legal support to inventors and start-ups, and increase public awareness about IP rights. (WIPO, 2022). Strengthening the Nigerian Copyright Commission and Patent Registry would help build trust in the innovation system and promote creativity.

c. Expand Innovation Hubs and Incubation Centres: To nurture emerging innovators, there should be an intentional scaling up of innovation hubs and incubation centres across Nigeria, especially in underserved regions. These centres should provide access to mentorship, R&D facilities, seed funding, and business development support. (UNESCO, 2021; NITDA, 2024). Government and private sector partnerships can ensure sustainability and effectiveness.

d. Promote Triple Helix Collaboration (Government-Academia-Industry): The government should facilitate structured collaborations among academia, research institutions, industries, and government agencies. This can be achieved through joint research funding, innovation consortia, public-private partnerships, and innovation-focused policy dialogues. Such collaborations will improve knowledge transfer, enhance R&D outputs, and create synergies in policy formulation and implementation.

e. Stabilize and De-risk High-Technology Export Capacity: Given the pronounced volatility observed in high-technology exports over the study period, including a sharp single-year spike in 2015 followed by a collapse to roughly pre-2009 levels by 2019, policy support for this sector should prioritize diversification across multiple high-tech product lines and firms rather than reliance on a small number of large, order-driven shipments. Complementary measures, such as export credit guarantees, quality-standards certification support, and market-diversification assistance, would help convert episodic export spikes into a more sustained upward trajectory.

By implementing these policy recommendations, Nigeria can significantly enhance the effectiveness of its STI indicators, bridge existing innovation gaps, and position itself as a competitive, knowledge-driven economy in Africa. Furthermore, a coordinated and inclusive STI strategy will empower youth, improve livelihoods, and contribute meaningfully to achieving the Sustainable Development Goals (SDGs).

REFERENCES

African Union Commission. (2020). *Digital transformation strategy for Africa (2020-2030)* (pp. 19–44). African Union.https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030

African Union. (2014). Science, Technology and Innovation Strategy for Africa 2024 (STISA- 2024). African Union Commission.

Ajibo, H. T., Edeh, F. O., & Nwogbo, V. N. (2019). Technology Transfer and Innovation Capability in Developing Countries: The Case of Nigeria. *International Journal of Technology Management & Sustainable Development*, *18*(2), 149-164.

Amukowa, W., &Ayuya, C. (2013). The Role of Science and Technology Education in National Development: The Case of Kenya. *International Journal of Academic Research in Progressive Education and Development*, *2*(1), 33-44.

Central Bank of Nigeria (CBN). (2020). "Annual Report 2020". [online] Abuja: Central Bank of Nigeria. Available at: https://www.cbn.gov.ng/

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics (4th ed.). Sage.

Freeman, C. (1995). The National System of Innovation in Historical Perspective. *Cambridge Journal of Economics.*

Freeman, C., & Soete, L. (2009). Developing Science, Technology and Innovation Indicators: What We Can Learn from the Past? In The Economics of Industrial Innovation (3rd ed.). Routledge.

Global Innovation Index (GII) 2022. World Intellectual Property Organization.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). Multivariate Data Analysis (7th ed.). Pearson.

Helms, M. M., & Nixon, J. (2010). Exploring SWOT analysis – where are we now? A review of academic research from the last decade. *Journal of Strategy and Management*, *3*(3), 215–251.

Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: Principles and Practice (2nd ed.). O Texts.

Lundvall, B.-Å. (1992). National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter.

NACETEM. (2024). Science, Technology and Innovation (STI) policy environment review in Nigeria. National Centre for Technology Management.

National Bureau of Statistics (NBS). (2020). "Nigerian Gross Domestic Product Report Q2 2020". Abuja: NBS.

National Bureau of Statistics (NBS). (2022). Nigeria Labour Force Survey 2022. Abuja: National Bureau of Statistics.

National Information Technology Development Agency. (2024). *Strategic roadmap and action plan (SRAP 2.0) 2024–2027*. NITDA. https://nitda.gov.ng

OECD. (2015). Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. OECD Publishing. (7th ed., pp. 1–400).

Siyanbola, W., Adeyeye, A., Olaopa, O., & Hassan, O. (2016). Science, technology and innovation indicators in policymaking: The Nigerian experience. *Palgrave Communications*, *2*(1). 1-9.

UNDP. (2020). Human Development Report 2020: The Next Frontier – Human Development and the Anthropocene. United Nations Development Programme.

UNESCO Institute for Statistics. (2019). Data for Sustainable Development Goals. [Online database]. Montreal: UNESCO Institute for Statistics. Available at: http://data.uis.unesco.org/.

UNESCO Institute for Statistics. (2021). Science, technology and innovation indicators. https://uis.unesco.org/en/topic/science-technology-and-innovation.

UNESCO. (2021). UNESCO science report: The race against time for smarter development. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000377433

United Nations. (2020). "World Population Prospects 2019: Highlights". New York: United Nations.

WIPO. (2022). World intellectual property report: The direction of innovation. World Intellectual Property Organization. https://www.wipo.int/publications.

World Bank. (2020). Research and Development Expenditure (% of GDP).

World Bank. (2021). *Nigeria development update (June 2021): Resilience through reforms* (Report No. 160339, pp. 1–84). World Bank Group. https://openknowledge.worldbank.org/entities/publication/9c7056ec-045e-57d5-9e42-4b89e2c414ca

World Bank. (2024). World Development Indicators. https://databank.worldbank.org/source/world-development-indicators