Education, Innovation, and Knowledge Economy in Advancing Sustainable Development Goals: A Multidisciplinary Study

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| **Abstract** | The study investigates how key elements of the knowledge economy, human capital, innovation systems, ICT infrastructure, and institutional frameworks shape the performance of selected Sustainable Development Goals (SDGs). Drawing on theoretical insights from Endogenous Growth Theory, Schumpeterian Innovation Theory, and Institutional Theory, the research adopts a quantitative design using data obtained from 218 respondents across academia, public-sector agencies, and private organisations. A combination of exploratory and bivariate analyses, with multiple correlations, was applied to investigate these connections. The results reveal that human capital is the most influential determinant of SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). At the same time, ICT infrastructure is the strongest driver of SDG 9 (Industry, Innovation, and Infrastructure). Institutional fitness significantly contributes to SDG 16 (Peace, Justice, and Strong Institutions) and also moderates the effect of innovation systems on SDG outcomes. Reliability indices (mean Cronbach's α = 0.87) and sampling adequacy tests (KMO = 0.81) confirm a robust measurement structure. The study concludes that strengthening the pillars of the knowledge economy facilitates broad-based progress toward multiple SDGs simultaneously. Consequently, policymakers should prioritise investments in education, digital technology, innovation ecosystems, and governance reforms to foster inclusive, knowledge-driven, sustainable development. |

INTRODUCTION

Over the past three decades, global development thinking has shifted from a narrow focus on economic growth to a broader emphasis on sustainability, inclusiveness, and innovation-driven transformation. The adoption of the Sustainable Development Goals (SDGs) in 2015 reflects this paradigm shift, providing a comprehensive framework for addressing persistent challenges related to education, employment, industrialisation, governance, and social equity (Gore, 2015). However, despite widespread commitment to the SDGs, progress has been uneven, particularly in developing economies where structural constraints continue to undermine sustainable development outcomes.

One of the most critical challenges confronting developing countries is translating economic growth into sustainable, inclusive, and resilient development. The knowledge economy (KE) provides such an opportunity. Knowledge economies are those in which the generation, distribution, and use of knowledge are the dominant drivers of wealth and economic growth (OECD, 1996; Becerra-Fernandez & Sabherwal, 2001). Traditional growth models that rely heavily on natural resources and low-skilled labour have increasingly proven inadequate in addressing contemporary development needs (OECD, 1996; World Bank, 2007). In response, scholars and international institutions have highlighted the growing importance of the knowledge economy, in which human capital, innovation systems, information and communication technologies (ICT), and effective institutional frameworks serve as the primary drivers of productivity and long-term development (Kosor, 2023; Nosratabadi et al., 2023). While the knowledge economy has been widely studied, its concrete role in accelerating progress toward specific SDGs remains insufficiently understood, especially in national contexts characterised by institutional fragility and development asymmetries.

Existing empirical research has largely examined isolated components of the knowledge economy or focused on individual SDGs, most commonly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), or SDG 9 (Industry, Innovation and Infrastructure) (Dellve et al., 2025; Gadre & Deoskar, 2024; Kreinin & Aigner, 2022; Makarenko et al., 2021; Shafik, 2025). Fewer studies have adopted an integrated approach that simultaneously links multiple pillars of the knowledge economy to numerous, interconnected SDGs. Moreover, governance and institutional quality, central to SDG 16 (Peace, Justice and Strong Institutions), are often treated as background conditions rather than explicitly tested mechanisms that shape the effectiveness of knowledge-based development strategies. As a result, the current state of the literature provides fragmented insights and limited policy guidance, particularly for countries undergoing uneven transitions toward knowledge-driven development.

Nigeria presents a compelling empirical context for addressing these gaps. As Africa's largest economy and most populous nation, Nigeria faces persistent challenges related to education quality, youth unemployment, weak innovation systems, digital inequality, and governance deficits, all of which directly affect SDG performance (Obute, 2021; Ogwu, 2025; Okonkwo, 2024; Oluwatomi Shobayo, 2025). At the same time, the country has experienced rapid expansion in higher education, ICT adoption, and innovation hubs, creating an opportunity to empirically assess whether and how components of the knowledge economy

are translating into sustainable development outcomes. Understanding this nexus is particularly urgent, given the limited time remaining to achieve the 2030 Agenda and the increasing pressure on policymakers to prioritise evidence-based development strategies.

Against this backdrop, the present study is motivated by the need to provide systematic, empirical, and policy-relevant evidence on the role of the knowledge economy in advancing sustainable development. Drawing on Endogenous Growth Theory, Schumpeterian Innovation Theory, and Institutional Theory, the study develops an integrative framework that links four core pillars of the knowledge economy: human capital development, ICT infrastructure, innovation systems, and institutional quality to selected SDGs (4, 8, 9, and 16). Unlike previous studies, this research makes three key contributions. First, it empirically examines multiple SDGs within a single analytical framework, capturing their interdependence. Second, it explicitly models institutional quality as a moderating factor that conditions the impact of innovation on development outcomes. Third, it employs stakeholder-based survey evidence from Nigeria, offering context-specific insights that complement macro-level cross-country analyses. By addressing these gaps, the study advances the state of the art on knowledge-driven development. It provides actionable insights for policymakers, educators, and development practitioners seeking to leverage the knowledge economy to achieve sustainable and inclusive growth.

THEORETICAL LITERATURE

The theory for this study comes from several subfields of the literature on the knowledge economy (KE) and its impacts on sustainable development, institutional theories of development, human capital theory, and theories of innovation systems. All of the above theories will be taken into account, including possible integrations, to outline the study's context with respect to KE and the SDGs.

The Term Knowledge Economy

The OECD acknowledged the concept of the Knowledge Economy in the 1990s. They defined the knowledge economy as one in which growth relies on information and knowledge as the primary drivers of wealth creation, rather than traditional factors such as physical labour, land, and capital (Chen et al., 2024). The World Bank describes the key factors of the knowledge economy as (1) an effective Institutional and regulatory framework; (2) an educated and skilled workforce; (3) Flexible and efficient information and communication

technologies (ICT), and (4) an effective system of innovation. The framework identifies the creation, dissemination, and application of knowledge as central to productivity and competitiveness. Becker (2012) Human Capital Theory argues that knowledge is capital in the economy. Knowledge capital pertains to the growth and productivity of an economy, which comes from individuals' earnings, education, and skills. The institutional economists' work elucidates the role of institutions (rules and governance) and the frameworks of regulation in the effective (or ineffective) use of knowledge. The innovation systems theory of Lundvall, 1992; Freeman, (1995) associates innovation, learning, knowledge, and technology with economic value. A knowledge economy encompasses more than information and communication technology (ICT) and other types of infrastructure. It entails the seamless integration of these elements into a cohesive whole and system for creating value.

Sustainable Development Theory and the SDGs

Sustainable development revolves around the central principles of economic growth, social inclusion, and environmental protection, and integrates them as the interrelated pillars (Hariram et al., 2023). In 2015, UNO adopted the SDGs and structured these three integral pillars around 17 goals as a normative framework. There are numerous theories of sustainable development, many of which focus on systems thinking, complexity, and interdependence. For instance, the 'planetary boundaries' framework (Rockström et al., 2009) and the 'capabilities approach' (Sen, 1999) prioritize human well-being and agency as the central focus instead of mere economic factors. From this perspective of sustainable development theory, the knowledge economy theory can arguably be understood the same way. The KE theories explain how knowledge assets sustain growth and innovation, while the sustainable development theory elaborates on the growth focus as purposeful toward inclusion, equity, and ecological resilience.   The Integrative Conceptual Framework: KE → SDGs.

Building on these theoretical perspectives, the present study offers a conceptual framework in which the components of the knowledge economy are positioned as drivers of particular SDG outcomes, tempered by institutional and governance quality. Personal understanding of an area cannot be rationally developed unless growth occurs through human capital development. Such growth is focused on achieving SDG 4 (Quality Education) and, through this, achieving SDG 8 (Decent Work) and SDG 9 (Innovation). Specifically, ICT infrastructure and the development of communication technologies advance SDG 9 (Innovation) by promoting access, inclusion, and productivity in SDG 4 (Quality Education)

and SDG 8 (Decent Work). Innovation systems that include R&D, entrepreneurial endeavours, and the flow of knowledge and ideas all support advancements to SDG 9. These systems also enhance productivity and decent work (SDG 8), thereby contributing to inclusive economic growth. The institutional and regulatory frameworks govern quality systems, policies, and the rule of law. These systems and frameworks facilitate the translation of key factors of the knowledge economy into the SDGs, thus linking to SDG 16 (Peace, Justice, and Strong Institutions). Lastly, the operation of the knowledge economy is a rational progression toward achieving the SDGs. For example, an educated populace fuels innovation, and the cycle of improvement works in a positive way.

EMPIRICAL LITERATURE REVIEW

The current empirical literature examines the knowledge economy and sustainable development and acknowledges the importance of knowledge-based assets and institutions, as well as their effects on the Sustainable Development Goals (SDGs). For example, the 2025 publication Governance Quality and Sustainable Development: Insights from the United Nations Sustainable Development Goals in Africa contends that, from 2010 to 2022, governance quality in 48 African countries facilitated sustainable economic, social, and environmental development (Rockström et al., 2024). He also mentions that the absence of governance weakens knowledge-economy investments on the governance SDGs, further supporting the institutional regimes as a moderating factor in our framework. While assessing the sustainability of studies on air pollution in the Niger Delta Region of Nigeria, Udoinyang (2025) reports that air pollution in the Region is responsible for roughly 12,000 natural deaths annually and is associated with an annual health cost of 3.8 billion dollars and 4 trillion naira. Such findings underline the urgent need to reform policies focused on alleviating the Region's air pollution, controlling pollution from industrial, vehicular, and other sources, and making further investments in the Region's health infrastructure to mitigate the adverse health effects of air pollution. It would provide an opportunity to study the implications of air pollution on human health and the economy, and the environmentally equitable progress of the Niger Delta Region. The 2023 publication, Social Sustainability of Digital Transformation: Empirical Evidence from the EU-27 Countries, analyses the social sustainability of the SDGs and the knowledge economy within the scope of digital transformation in EU-27 countries, as well as social sustainability as a phenomenon and the social-inequality divide post-2020. The EU-27 countries have also been discussed in terms of social inequality polarization, specifically the

rich-poor divide. It is claimed that transformative sustainable digitalization, encompassing sustainable policies, can promote equitable social attainment of certain SDGs. Thulstrup and Hegedus (2023) emphasize that inequality, particularly as measured by the Gini coefficient, is a hidden paradox in the underachievement of the SDGs. Elements of the digital economy (ICT infrastructure and digitalisation) positively impact SDG outcomes, but only if social equity and inclusion are preconditions (Thulstrup & Hegedus, 2023).

In the article titled SDG 4 and SDG 8 In The Knowledge Economy: A Meta-Analysis In The Context of Post-COVID-19 Recovery (Makarenko et al., 2021), the author focuses on the melding of educational systems and labour markets as core factors of the knowledge economy and its relevance to SDG 4 and SDG 8 during the phases of transitioning to the knowledge economy. Makarenko et al. (2021) considers the COVID-19 pandemic as an overwhelming obstacle to the simultaneous achievement of both goals, while also asserting that the preparedness of the knowledge-based economy was uneven and influenced by particular structural configurations. Examining the role of education in the Sustainable Development Goals (SDGs), Abera (2023) noted that the knowledge economy is underdeveloped, with a poorly articulated and disseminated discourse on its potential to advance some SDGs. In light of the discourse that has been constructed and the evolution of the knowledge economy, the present study aims to address the highlighted gaps.

1) Although the empirical work primarily considers one or two SDGs, such as SDG 4, SDG 8, and SDG 9, only a small number of works integrate multiple SDGs with the constituents of the knowledge economy. However, some integration of these constituents with several SDGs has been achieved.

2) Although some empirical studies have examined broader geographical areas such as the EU or Africa as a whole, few have examined the specific country context of, for example, Nigeria, where knowledge economy transitions and gaps in the SDGs are most pronounced and visible.

3) The incorporation and testing of governance and the institutional framework as a formal moderator, especially in quantitative or survey-based studies that aim to bridge the knowledge economy with the SDGs, remain largely unexamined.

4) Advocacy Studies and Outcome-Based Assessments concerning Practical and Outcome Integration: Some scholarly works take a more macro view, but stakeholder perceptions of the Knowledge Economy and the attainment of the SDGs have largely remained in the shadows.

5) The Knowledge Economy and the Attainment of the SDGs: While the digital economy is expanding, institutions are increasingly integrating technology, and there are transitions toward knowledge-economy structures, there is still a lack of evidence within the timeframe of 2023 to 2025.

This research attempts to close some of those gaps within a national context comprising various pillars of the knowledge economy and multiple interconnected SDGs, and to conduct an empirical survey-based study, with the institutional framework examined as a moderating variable.

METHODOLOGY

This research involved Nigeria as a participant in the globalization of the knowledge and information economy, as well as a country with rapidly improving ICT infrastructure and innovation hubs, and efforts toward the SDGs (Sustainable Development Goals). Nigeria was selected because of its role in regional development planning and its burgeoning knowledge economy. The population of the study consisted of stakeholders within the knowledge economy and sustainable development for the Region which included (1) senior administrators and academic staff of the tertiary institutions; (2) managers of the innovation hubs/technology incubators; (3) development policy officials at the state level; and (4) civil society organisations concerned with sustainability and skills development.

The research employed a multistage sampling technique (Handa et al., 2016). For the first stage, purposive sampling was used to select institutions and organizations with the greatest relevance to the knowledge economy and SDG activities. For each purposively designated institution and within the several population sampling layers (academics, innovation hub managers, policy officials, and NGO representatives), the remaining population was stratified to select respondents. A target sample size of 250 was determined for the study. Social science research methodologies suggest that this sample size will adequately address the proposed correlation and regression analysis with a statistical power of 95% and a margin of error of ±5%.

The study ended with a final sample of 218 usable questionnaires after adjustments for non-responses. The first step involved the creation of a structured questionnaire that included several Likert scale items (1- Strongly Disagree, 5- Strongly Agree) that centred on the four pillars of a knowledge-economy: Human Capital Development, ICT infrastructure & access, Strength of the Innovation System, the Institutional/Regulatory regime and the respondent's

opinion on the contribution to SDGs (SDG 4, SDG 8, SDG 9, SDG 16) and associated SDGs. Questions on barriers/enablers, as well as demographic information (role, years of experience, institution type), were also included. The questionnaire underwent a pre-test with 30 respondents (target reliability: Cronbach's alpha > 0.70). The questionnaires were administered face-to-face (physical drop-off) and electronically (email/Google Forms). The initial data collection spanned 4 weeks and included follow-up reminders to retrieve data, sent via both electronic and physical methods. Data entry and clean-up were conducted using Microsoft SPSS V. 27 (2020) software.

DATA ANALYTICAL STRATEGIES

In this analysis, the investigator uses descriptive statistics (mean, standard deviation, etc.) to summarize the results quantitatively.

Table 1. Descriptive Statistics for Knowledge-Economy Variable SDG Outcomes

Research Question (RQ)	Variable (s)	Items/ Indicators	Mean (M)	Standard Deviation (SD)	Interpretation
RQ1: Relationship between KE pillars and SDG outcomes	Knowledge-Economy Composite Index	Human capital, ICT, innovation, institutional regime	3.59	0.69	Moderate perceived contribution of EK pillars to SDG outcome
RQ2: Human capital and SDG & SDG 8	Human Capital Development	Education quality, workforce skills, training, retention	3.87	0.62	Strong perceived contribution to education and decent work
	SDG 4: Quality Education	Access, inclusiveness, lifelong learning	3.92	0.65	Moderate-to-high performance
	SDG 8: Decent Work & Economic Growth	Employment, productivity, inclusive growth	3.66	0.69	Moderate progress
RQ3: ICT and SDG 9	ICT Infrastructure	Internet access, inclusiveness, lifelong learning	3.75	0.68	Moderately strong ICT foundation
	SDG 9: Industry, Innovation &	R&D capacity, tech adoption, industrial	3.21	0.79	Moderate progress but uneven

Research Question (RQ)	Variable (s)	Items/ Indicators	Mean (M)	Standard Deviation (SD)	Interpretation
	Infrastructure	modernisation			
RQ4: Innovation system & institutions	Innovation System Strength	R&D, entrepreneurship, collaboration	3.44	0.71	Moderate innovation activity
	Institutional Regime	Governance, regulation, policy	3.31	0.73	Weak-to-moderate institutional support
	SDG 16: Peace, Justice & Strong Institutions	Governance, rule of law, public trust	3.15	0.80	Weak institutional effectiveness
RQ5: Institutional moderation	Institutional Innovation (Interaction)	Moderate variable	$\beta = 0.18$ (p < 0.05)	-	Positively moderated: strong institutions amplify innovation impact.

Interpretation Summary

1) The overall mean scores suggest moderate agreement (M = 3.15–3.92) that knowledge-economy components contribute to SDG outcomes.

2) The highest-rated variable is Human Capital Development (M = 3.87), showing that education and skills are perceived as most advanced.

3) The lowest-rated variable is SDG 16 (Institutional Effectiveness) (M = 3.15), revealing governance weaknesses.

4) The moderating effect ($\beta = 0.18$, p < 0.05) supports the hypothesis that better institutions strengthen the link between innovation systems and decent-work outcomes.

Table 2. Correlation Matrix among Knowledge-Economy Pillars and SDG Outcomes (n = 218)

Variables	1	2	3	4	5	6	7	8
1. Human Capital Development	1.00							
2. ICT Infrastructure	0.48**	1.00						
3. Innovation System Strength	0.52**	0.43**	1.00					
4. Institutional	0.41**	0.37	0.49**	1.00				

Variables	1	2	3	4	5	6	7	8
Regime								
5. SDG 4: Quality Education	0.62**	0.38**	0.44**	0.35**	1.00			
6. SDG 8: Decent Work & Growth	0.57**	0.46**	0.52**	0.39**	0.54**	1.00		
7. SDG 9: Industry & Infrastructure	0.41**	0.48**	0.50**	0.33**	0.42**	0.47**	1.00	
8. SDG 16: Institutions	0.36**	0.31**	0.39**	0.59**	0.33**	0.41**	0.35**	1.00

Note. $p < 0.05$, $p < 0.001$ (two-tailed).

All variables are measured on a 5-point Likert scale (1 = Strongly Disagree → 5 = Strongly Agree)

Table 3. Multiple Regression Results for Predictors of SDG Outcome

Dependent Variable (SDG)	Independent Variables (Predictors)	Standardised Beta (β)	t-Value	Sig. (P)	R^2	F-Statistic	Model Sig.
Model 1: SDG 4 (Quality Education)	Human Capital Development	0.57	9.48	0.000**	0.38	49.78	0.000**
Model 2: SDG 8 (Decent Work)	Human capital →	0.27	2.42	0.017*	0.42	55.33	0.000**
	Innovation System Strength →	0.39	3.71	0.001**			
Model 3: SDG 9 (Industry & Infrastructure)	ICT infrastructure →	0.43	5.88	0.000**	0.41	52.16	0.000**
	Innovation System →	0.31	3.02	0.003**			
Model 4: SDG 16 (Institutions)	Institutional Regime	0.51	8.35	0.000**	0.35	45.24	0.000**
Model 5: Moderation (SDG 8)	Innovation x Institutional Regime (Interaction)	0.18	2.11	0.036*	0.47	33.67	0.00088

Note. $p < 0.05$, $p < 0.01$ (2-tailed).

All models satisfy normality, linearity, and homoscedasticity assumptions.

Interpretation Summary

Human capital is the most significant predictor of SDG 4 (β = 0.57, $p < 0.001$).

Human capital and innovation systems together predict SDG 8 ($\beta = 0.39$, $p < 0.01$; $\beta = 0.27$, $p < 0.05$).

SDG 9 is influenced by ICT infrastructure and innovation systems.

Institutional regime is a strong predictor of SDG 16 ($\beta = 0.51$, $p < 0.001$).

The positive interaction term indicates that institutional quality ($\beta = 0.18$, $p < 0.05$) moderates the innovation system's effect on decent-work outcomes.

Table 4. Reliability and Validity of Constructs

Construct / Variable	No. of Items	Cronbach Alpha (α)	Composite Reliability (CR)	Average Variance Extracted (AVE)	Kaiser Mayer Olkin (KMO)	Interpretation
Human Capital Development	6	0.884	0.903	0.628	0.831	Excellent reliability and convergent validity
ICT Infrastructure	5	0.861	0.876	0.597	0.802	Very good internal consistency
Innovation System Strength	6	0.873	0.888	0.615	0.845	Highly reliable and valid
Institutional Regime	6	0.857	0.871	0.582	0.817	Acceptable reliability; strong construct adequacy
SDG 4: Quality Education	4	0.834	0.851	0.603	0.788	Reliable and valid measure
SDG 8: Decent Work & Economic Growth	5	0.862	0.880	0.610	0.822	High consistency and validity
SDG 9: Industry, Innovation & Infrastructure	5	0.848	0.864	0.583	0.801	Reliable and internally consistent
SDG 16: Peace, Justice & Strong Institutions	5	0.828	0.846	0.567	0.776	Acceptable reliability and convergent validity
Overall Measurement Model	-	0.873 (Average)	0.885 (Average)	0.598 (Average)	0.810 (Average)	Satisfactory model reliability and validity

Interpretation Summary

1) All Cronbach's Alpha values are above the 0.70 threshold → indicating strong internal consistency.

2) Composite Reliability (CR) values (≥ 0.85) confirm that each construct reliably measures its intended dimension.

3) Average Variance Extracted (AVE) values (≥ 0.50) indicate good convergent validity, indicating that the latent constructs explain more than half of the variance in their observed indicators.

4) KMO values (> 0.70) indicate adequate sampling for factor analysis and overall construct validity.

5) Therefore, the measurement model is statistically sound and appropriate for further analyses related to regression and structural modelling.

RESULTS AND DISCUSSION

This research explored the linkages between the four major factors of the knowledge economy (KE): human capital, ICT infrastructure, innovation systems, and institutional regimes, and the attainment of selected Sustainable Development Goals (SDGs 4, 8, 9, and 16). The empirical results revealed several substantial interconnections that corroborate the theoretical foundations of knowledge-driven development.

Human Capital Development and SDG 4 (Quality Education)

Regression results ($\beta = 0.57$, $p < 0.001$) show that human capital development strongly predicts progress on SDG 4 (Quality Education). This finding is in line with endogenous growth theory (Aghion et al., 2023; Romer, 1990), which argues that investments in education and skills training lead to long-term gains in productivity, realized through innovation and knowledge diffusion, thereby asserting that the economy's potential will be realized.

This conclusion is supported by recent empirical research. In Nigeria, for instance, Adeoye and Otemuyiwa (2024) revealed that the insertion of digital skills training and tertiary education enrolment directly contributed to SDG 4 targets by improving employability and innovation potential. Across the OECD (Ahn, 2024), nations that accumulated human capital more rapidly progressed toward the education-related SDGs, reporting improvements in the quality of teaching, technological integration into teaching processes, and more inclusive access to education. Uninterrupted human capital investments, especially in teacher professional development and digital learning infrastructure, are fundamental to realizing SDG 4 and to facilitating other SDGs through the power of skills and human potential.

Human Capital and Innovation as Predictors of SDG 8 (Decent Work and Economic Growth)

Human Capital Development (β = 0.27, p < 0.05) and the Innovation System Strength (β = 0.39, p < 0.01) were both found to significantly predict SDG 8 (Decent Work and Economic Growth). This result substantiates the Schumpeterian innovation theory, which holds that technological innovation creates new jobs and stimulates the flow of economic growth (Akpan & Mbah, 2023).

According to the World Bank (2022), innovation-driven economies provide greater job opportunities and economic productivity, corroborating economic theory through entrepreneurial ecosystems and digital transformation. In addition, Obasi and Kareem (2025) and this study noted that Sub-Saharan African regions investing in workforce reskilling and innovation hubs experienced increased industrial output and lower unemployment. Therefore, the Human Capital and Innovation Nexus endorses economic diversification, increased productivity, and sustainable employment, which are fundamental to SDG 8.

ICT Infrastructure and SDG 9 (Industry, Innovation, and Infrastructure)

A correlation of 0.48 (p < 0.01) indicates a strong positive relationship between the SDG 9 indicator and ICT infrastructure, a relationship that the regression analysis also captures (β = 0.43, p < 0.001) as the strongest predictor of industrial innovation and infrastructure development. These results affirm the WorldBank (2024) Knowledge Economy Framework and Ndubuisi (2022) Digital Transformation Theory, which argue that industrial development is built on a strong foundation of digital infrastructure that supports innovation, connectivity, and production efficiency.

Recent studies, such as Wang (2024) in China and Eboh et al. (2024) in Nigeria, empirically confirmed that the penetration of broadband and the diffusion of ICT positively impact innovation and industrial competitiveness. Consequently, through knowledge transfer, technological diffusion, and productivity enhancement, ICT infrastructure serves as a primary enabler of SDG 9. The Relationship between Institutional Regime and SDG 16 (Peace, Justice, and Strong Institutions). The relation between the quality of an institutional regime and SDG 16 is also positive and statistically significant (β = 0.51, p < 0.001). Attention to governance, rule of law, and transparency strengthens the case for fully incorporating these facets into sustainable development. This finding is consistent with Institutional Theory (North, 1990; Rodrik, 2023), which suggests that robust institutions provide the necessary framework for innovation and equitable resource distribution.

The work of the UNDP (2023) and Adeleke et al. (2023) provides further evidence that countries with sophisticated governance systems also attract greater foreign direct investment and perform better across numerous SDG criteria. Weak institutions, on the other hand, curtail innovation and entrepreneurial activity and increase inequality. The results of this study, therefore, confirm the hypothesis that the quality of institutions is a direct driver of SDG 16 and a further moderator of the positive impacts that innovation systems have on economically sustainable growth.

The Interaction of Institutional Quality and Innovation: Assessing Impact on SDG Outcomes. The results of the interaction term analysis ($\beta = 0.18$, $p < 0.05$) indicate a moderate institutional effect on the linkage between innovation systems and SDG outcomes, particularly SDG 8. Innovation's effects on growth are even greater in contexts of effective and civically responsible governance.

The findings align with the extended Systems of Innovation Theory (Chen et al., 2024; B.-Å. Lundvall, 2016), which emphasizes the importance of institutional frameworks in promoting innovation. The work of Oyelaran-Oyeyinka and Abejirin (2024) provides evidence that enhancing the absorptive capacity of innovation networks in Africa, particularly following institutional reforms, results in improved performance on the SDGs. Hence, without institutional integrity, the balance of innovation and its contribution to sustainable development disengages. Advanced technology must be accompanied by inclusive socio-economic progress.

INTEGRATION OF THEORY AND EVIDENCE

The three approaches to the knowledge economy support the theories of endogenous growth, Schumpeterian innovation, and institutions. It indicates the knowledge economy integrates human capital, innovations, and institutions as synergistic and cohesive to promote sustainable development. Most of the time, the World Bank and UNESCO (2024) publications are right about global trends. The results show global growth trends and conclude that countries that invest in education and research and development, coupled with governance reforms, achieve greater progress toward sustainable development goals. For the Nigerian case, and unlike the countries UNESCO (2024) and World Bank (2024) publications are describing, evidence shows the knowledge economy has been developing gradually in an uneven manner, pointing to the growth of structural gaps in the quality of education, digital infrastructure, and poorly constructed education institutions (Ogunleye et al., 2024).

The knowledge economy and governance reinforce the research hypothesis regarding the Sustainable Development Goals: strengthening the pillars of the knowledge economy advances the goals. The results and findings of this paper can be categorized in the following way:

1) The development of human capital explains the predictive value of the educational and economic SDG. It confirms the critical value of knowledge and skills in the economy.

2) Innovation systems considerably shape decent work and industrial growth. It validates the value of innovation systems in the growth and development of the economy.

3) The provision of ICT infrastructure fuels technological and industrial development and promotes digital inclusion.

4) The quality of governance systems enhances SDG-focused governance and, in turn, improves economic sustainability through innovation. It confirms the hypothesis that governance improves economic development and confirms the predictive value of the SDG economic goals.

5) The integration of all aspects of a knowledge economy offers a comprehensive approach to the simultaneous achievement of multiple SDGs.

Most importantly, this study shows that achieving the 2030 Agenda for Sustainable Development in all its dimensions depends on the knowledge economy, whose foundations are education, innovation, information and communication technology, and solid institutions.

CONCLUSION

This study set out to examine whether and how the key pillars of the knowledge economy contribute to the attainment of selected Sustainable Development Goals—specifically SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 16 (Peace, Justice and Strong Institutions) within the Nigerian context. Guided by the research questions and hypotheses, the analysis provides clear answers to the central research problem concerning the effectiveness of knowledge-based development strategies in advancing sustainable development.

The findings demonstrate that human capital development is the most decisive driver of education and decent work outcomes, confirming that investments in education, skills acquisition, and workforce development are foundational to sustainable economic progress. It directly answers the first research question by establishing a strong and positive relationship

between human capital and SDG 4 and SDG 8. In practical terms, the results indicate that without sustained improvements in education quality and skills formation, progress toward other development goals remains constrained. The study further shows that ICT infrastructure and innovation systems are critical enablers of industrialisation and economic transformation, providing clear responses to the second and third research questions. ICT infrastructure emerged as the strongest predictor of SDG 9, while innovation systems significantly influenced both industrial development and decent work outcomes. These findings highlight that digital connectivity and innovation capacity are not optional complements but essential conditions for productive and inclusive growth in a knowledge-driven economy.

Importantly, the analysis confirms that institutional quality plays both a direct and a conditioning role in sustainable development. Strong institutions significantly improve governance-related outcomes (SDG 16) and enhance the effectiveness of innovation systems in generating decent work and economic growth. This directly addresses the study's core problem formulation by demonstrating that knowledge economy investments yield optimal SDG outcomes only when supported by effective governance, regulatory coherence, and institutional trust. Overall, the study concludes that the knowledge economy offers a viable, integrated pathway to achieving multiple SDGs simultaneously, but its success depends on balanced investments across education, innovation, digital infrastructure, and institutions. For developing economies such as Nigeria, sustainable development cannot be achieved through isolated interventions or growth-focused policies alone. Instead, a coordinated strategy that strengthens the full ecosystem of the knowledge economy is required to accelerate progress toward the 2030 Sustainable Development Goals.

Study Limitations

The research offers important insights regarding the intersection of the knowledge economy and sustainable development. Nevertheless, there are important limitations to the study, including:

1. The research focused only on Nigeria and a small number of institutions in specific regions. As a result, the findings are unlikely to account for the full range of socio-economic and institutional diversity across other developing or developed countries.

2. The research design utilized a cross-sectional approach to data collection. Therefore, the study is unable to address issues of long-term causation across the various components of the knowledge economy and the outcomes associated with the SDGs. Longitudinal

studies in this area and context would be of great value to the field, as they would outline changes and shifts in components of the knowledge economy over time.

3. Even when validated tools are used, self-report techniques and surveys are always at risk of self-report bias. Future research could use more objective measures, such as national education spending, innovation indicators, and governance performance indicators, alongside the surveys.

4. The research focused only on four SDGs (4, 8, 9, and 16) due to their high theoretical and empirical relevance to the knowledge economy. Other SDGs, such as SDG 7 (Affordable and Clean Energy), SDG 10 (Reduced Inequalities), and SDG 13 (Climate Action), could also, to a lesser extent, contribute to the knowledge economy.

5. The impact of other possible mediating variables, such as social innovation, policy fragmentation, and digital exclusion, was also not explained, even though the influence of institutional quality as a moderator was analysed. These would further explain how the drivers of the knowledge economy operate to produce change in sustainable development.

6. Researchers often had to step in to facilitate data retrieval because respondents lacked a grasp of some technical knowledge-economy indicators. It could lead to slight bias at the interpretative level, though the reliability test did indicate consistency.

Further Study Recommendations

Based on the stated limitations, additional research is necessary in the following areas to clarify and enhance the present findings:

1. Future work should include cross-national or regional comparative studies within and across the Global South and Global North. It would reveal specific contextual differences regarding the impact of the various dimensions of the knowledge economy on the advancement of the SDGs in Sub-Saharan Africa and high-income countries.

2. Longitudinal studies of changes in human capital and innovation, as well as in institutional effectiveness, and the interplay among these elements over time, would clarify dynamic relationships and causation. Additionally, combining design and quantitative methods with in-depth qualitative interviews or a case study approach would enhance contextual interpretation.

3. The knowledge economy's contribution to other SDGs, particularly SDG 5 (Gender Equality), SDG 7 (Clean Energy), and SDG 13 (Climate Action), is also worth

investigating. It would further expand understanding of the knowledge economy and its impact on multidimensional sustainability.

4. The rapid advancement of digital tools warrants research on the impact of AI, machine learning, and other advanced forms of big data analytics on the transformation of knowledge creation and innovation flows, as well as the governance of institutions in the SDG arena.

5. Subsequent inquiries might analyse how national frameworks, governance reforms, and public–private partnerships can close the gaps in the knowledge economy and its influence on SDG outcomes. It will ensure the policy handles are inclusive and support evidence-informed policies.

6. Subsequent research might focus on the dynamics of specific sectors, such as education, manufacturing, or renewable energy, to develop strategies oriented to the knowledge economy and drive development in those sectors.

7. Considering the potential of regional innovation systems and transnational knowledge networks, further empirical research to identify mechanisms for accelerating SDG progress through South–South and North–South collaboration is worthwhile.

RECOMMENDATIONS

The findings lead to the following recommendations.

1. Educational institutions and governments should expand the provision of lifelong skills education and training to meet the demands of the knowledge economy. It should include problem-solving, critical thinking, and innovation.

2. Support the provision of reliable, high-speed broadband, smart infrastructure that fosters innovation and industrial transformation, and digital inclusion of unserved.

3. Foster partnerships for innovation and entrepreneurship, R&D collaboration, knowledge spillovers, and technology diffusion among universities, research institutions, start-ups, and government and industry.

4. Enhance arrangements to improve governance, transparency, and the rule of law, and rationalize knowledge economy initiatives for sustainable development and equitable access.

5. Building plans for the knowledge economy's vital components are to be mainstreamed as the SDGs are implemented. It will include education, innovation, infrastructure, and governance.

6. Knowledge economy interventions related to the SDGs should include an M&E framework that assesses their impact on the targeted SDG outcomes. It provides for efforts to respond to socio-spatial inequities through policy and program feedback loops.

7. A balanced knowledge economy should encompass marginalized, rural, and underserved communities. It is essential to mitigate rising disparities while upholding the SDGs 'leave no one behind' promise.

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