Insurance Market Development, ICT Diffusion, and Economic Growth in Sub-Saharan Africa

撒哈拉以南非洲保险市场发展、信息通信技术扩散与经济增长

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Abstract. This study extends the existing literature by examining the mediating role of information and communication technology (ICT) diffusion in the relationship between insurance development and economic growth in Sub-Saharan Africa (SSA). Using panel data from 36 SSA countries over the period 2007–2020 and applying the generalized method of moments (GMM), the results show that insurance penetration covering total, life, and non-life insurance along with ICT diffusion, significantly promotes economic growth in the region. The findings further indicate that ICT diffusion strengthens the growth-enhancing effect of insurance, highlighting its critical intervening role. Disaggregated ICT indicators reveal that fixed broadband, telephone subscriptions, and internet usage amplify the impact of total and life insurance penetration on economic growth, while fixed broadband plays a particularly strong role in enhancing the contribution of non-life insurance. Overall, the results suggest that although insurance development supports economic growth, its effectiveness is substantially reinforced through ICT infrastructure. Accordingly, the study underscores the importance for insurers to adopt digital technologies and leverage ICT diffusion to maximize their contribution to economic growth in SSA.

Keywords: Insurance market development, ICT diffusion, economic-growth

摘要: 本研究通过考察信息与通信技术（ICT）扩散在撒哈拉以南非洲（SSA）保险发展与经济增长关系中的中介作用，拓展了现有文献。研究使用了2007—2020年间36个撒哈拉以南非洲国家的面板数据，并采用广义矩估计法（GMM）进行分析。结果表明，涵盖总体保险、寿险和非寿险的保险渗透率以及ICT扩散，均能显著促进该地区的经济增长。研究进一步发现，ICT扩散强化了保险促进增长的效果，突显了其关键的中介作用。分项ICT指标显示，固定宽带、电话用户数和互联网使用率会增强总体保险和寿险渗透率对经济增长的影响，而固定宽带在提升非寿险对经济增长贡献方面的作用尤为显著。总体而言，研究结果表明，尽管保险发展能够支持经济增长，但其效果会通过ICT基础设施得到显著强化。因此，本研究强调，保险机构应积极采用数字技术并利用ICT扩散，以最大化其对撒哈拉以南非洲经济增长的贡献。

关键词： 保险市场发展、信息与通信技术扩散、经济增长，并在学科领域中较为常用

1. Introduction

Information and communication technology (ICT) plays a pivotal role in business operations and economic development by expanding market access, enhancing competitiveness, and improving access to knowledge and skills, particularly when applied to local challenges (Jayaprakash & Pillai, 2022; Qureshi, 2011). Over time, ICT has become an indispensable component of daily life, enabling communication, networking, and commercial activities for individuals and organizations alike (Ofori et al., 2022; Raifu et al., 2023). In Sub-Saharan Africa (SSA), governments increasingly recognize the transformative potential of ICT, as reflected in the growing number of digital initiatives and national technology agendas. Notable examples include Mobile Midwives in Ghana and Nigeria and the widespread adoption of M-Pesa across several African countries. These initiatives align with Africa's Sustainable Development Agenda 2030, which positions ICT as a foundational driver of sustainable development by promoting digital connectivity, broadband expansion, and technological infrastructure (SDGC, 2017). To accelerate digital transformation, SSA countries have also strengthened partnerships with global actors such as China and the European Union to enhance ICT infrastructure, digital skills, and innovation capacity (Abimbola et al., 2021).

The rapid expansion of ICT has been associated with institutional, social, financial, and economic development (SDGC, 2017), a trend further reinforced during the COVID-19 pandemic, which highlighted technology as a critical channel for business continuity. In SSA, rising adoption of mobile phones and internet connectivity has transformed several industries, including insurance, which plays a key role in promoting economic growth by providing financial security and risk mitigation for households and firms (Horvey et al., 2024). Despite its importance, insurance penetration in SSA remains the lowest globally, at approximately 2%. This underscores the need for innovative operational frameworks that improve accessibility, service delivery, and financial intermediation. ICT diffusion offers insurers digital platforms for product distribution, customer engagement, and data-driven innovation. The use of ICT reduces transaction costs, expands outreach to underserved populations, and facilitates the design of customized insurance products through behavioral data analytics (PwC, 2018). However, many developing countries lag behind their developed counterparts in leveraging ICT to meet market expectations, resulting in inefficiencies that constrain insurance sector development and broader economic growth (Aguegboh et al., 2023).

Against this backdrop, the central question remains how ICT diffusion strengthens the contribution of insurance market development to economic growth in SSA. ICT enables insurers to streamline claims processing, enhance customer responsiveness, promote digital insurance services, and improve information sharing, thereby increasing efficiency and trust within the industry (Asongu & Odhiambo, 2019; Sibindi, 2022). While ICT adoption presents challenges if neglected, it also offers substantial opportunities when strategically implemented (Witherspoon, 2015). Prior studies have separately examined the roles of ICT and insurance in economic development (Appiah-Otoo & Song, 2021; Balcilar et al., 2020; Pradhan et al., 2016), yet limited attention has been given to the moderating role of ICT diffusion in the insurance–growth nexus. This study addresses this gap by examining how ICT diffusion conditions the impact of insurance market development on economic growth in SSA. By disaggregating insurance penetration into total, life, and nonlife components, the study provides nuanced insights into sector-specific dynamics and offers policy-relevant evidence to support digital transformation strategies aligned with Africa's Sustainable Development Agenda 2030.

2. Materials and Methods

Theoretical underpinning

Globalization and the growing need for integrated growth-enhancing policies have heightened the relevance of social, financial, and economic development, thereby underscoring the interlinkages between ICT diffusion, insurance market development, and economic growth (Qureshi, 2015). This perspective is consistent with neoclassical information diffusion and growth theories, which emphasize the role of technology in facilitating financial development and economic expansion, particularly in developing economies (Solow, 1999; Bernard & Jones, 1996; Kwan & Chiu, 2015; Asongu & Odhiambo, 2019; Asongu et al., 2019). Neoclassical growth theory recognizes technological progress as a fundamental driver of long-run growth through productivity enhancement and process optimization at the firm level (Mase-nyetse & Manamathela, 2023). Consequently, the application of ICT across economic sectors, including insurance, improves operational efficiency, communication, innovation capacity, and productivity, which collectively stimulate economic growth (Jarraya et al., 2023).

From a broader development perspective, technological advancement is also linked to improvements in macroeconomic performance and household welfare, with insurance market development emerging as a key transmission channel (Asongu et al., 2019; Asongu & Odhiambo, 2019). The OECD (2017) further emphasizes that technological change is central to financial sector transformation, generating efficiency gains within insurance markets. These arguments align with the Sustainable Livelihood Approach (SLA), which posits that access to productive assets—such as ICT—enables economic agents and industries to create transformative growth opportunities (Duncombe, 2006). In contexts like Sub-Saharan Africa, where structural and administrative inefficiencies constrain financial development, ICT diffusion can enhance operational efficiency, expand market access, strengthen skills and social capital, and improve adaptive capacity. Collectively, these mechanisms support sustainable livelihoods while reinforcing industrial development and long-term economic growth.

ICT diffusion

Information and communication technology (ICT) diffusion is widely recognized as a key driver of economic development in both developed and developing economies. ICT stimulates growth by fostering innovation in products, processes, and business models, reducing operational and transaction costs, accelerating revenue generation, and strengthening firms' competitive advantage (Jayaprakash & Pillai, 2022; Chatterjee, 2020). Improved communication and information flows enabled by ICT lower user costs and support innovation, thereby contributing to business expansion, financial deepening, and overall economic development (Chatterjee, 2020; Qureshi & Najjar, 2017).

A growing body of empirical literature has examined the ICT–growth nexus, though findings remain mixed (Appiah-Otoo & Song, 2021; Awad & Albaity, 2022; Benlagha & Hemrit, 2020; Das et al., 2018). Some studies report a strong positive effect of ICT on growth, particularly in Sub-Saharan Africa (SSA). For instance, Das et al. (2018) identify a significant positive relationship between ICT diffusion and economic growth, with ICT–financial development interactions further reinforcing growth. Similarly, Appiah-Otoo and Song (2021) show that mobile, internet, and fixed broadband technologies enhance growth in both high- and low-income countries, with relatively larger gains observed in poorer economies. Conversely, other studies suggest that the growth-enhancing effects of ICT depend on development thresholds and complementary factors. Lee et al. (2005) argue that ICT investment promotes growth mainly in developed economies due to stronger infrastructure, while Röller and Waverman (2001) find that ICT significantly affects growth only after reaching a critical adoption level.

More recent evidence highlights the indirect and conditional role of ICT in promoting growth. Gheraia et al. (2022) document that ICT diffusion exerts an indirect positive effect on economic growth through financial development. Awad and Albaity (2022) further demonstrate that education, openness, and domestic investment are essential in strengthening the ICT–growth relationship, while ICT also contributes to social development by enhancing human capital. These findings align with Qureshi's (2015) argument that ICT for development improves welfare—especially for poorer populations—by expanding access, usage, and digital skills. In a related strand, Asongu et al. (2020) show that ICT diffusion moderates the relationship between governance and growth, suggesting that technology enhances institutional effectiveness and growth dynamics.

Insurance and Economic Growth

The relationship between insurance market development and economic growth has attracted substantial attention in the literature. A dominant theoretical explanation is the supply-leading hypothesis, which posits that financial sector development—particularly insurance—stimulates economic growth by mobilizing savings, enhancing capital formation, and supporting productive investment (Pradhan et al., 2016; Alhassan & Fiador, 2014). From this perspective, a well-functioning insurance market promotes long-term investment, improves risk-sharing mechanisms, and strengthens the economy's capacity for risk-taking, thereby accelerating growth.

Empirical evidence largely supports this view, although results vary across contexts. Sawadogo et al. (2018) document that life insurance development significantly boosts economic growth, while Akinlo and Apanisile (2014) show that insurance markets foster growth by providing long-term investment funds and mitigating risk. Similarly, Apergis and Poufinas (2020) find that insurance penetration—both life and nonlife—exerts a positive and significant effect on growth before and after the global financial crisis, highlighting the resilience of the insurance sector. Balcilar et al. (2020) further explain that insurance influences growth through multiple channels, including risk pooling, financial intermediation, fund mobilization, indemnification against losses, and investment facilitation. In contrast, Lee et al. (2016) report a negative insurance–growth relationship, attributing this outcome to weak institutional environments.

Additional studies reveal that the insurance–growth nexus may differ across time horizons and countries. Balcilar et al. (2020) provide evidence of both short-run and long-run effects, while Olayungbo and Akinlo (2016) identify short-run negative but long-run positive impacts for selected SSA countries. Alhassan and Fiador (2014) similarly confirm long-run growth effects arising from insurers' mobilized funds. Causality analyses also yield mixed findings: Akinlo (2015) reports bidirectional causality between insurance and growth in SSA, whereas Okonkwo and Eche (2019) find unidirectional causality within BRICS economies, emphasizing country-specific institutional and economic conditions.

Overall, the literature underscores the importance of insurance as a key mechanism for risk management and economic development. However, the heterogeneity of findings suggests that the insurance–growth relationship is context-dependent and not yet fully understood. As noted by Asongu and Odhiambo (2020), analyzing the direct link between insurance and growth is insufficient, highlighting the need for further empirical research that incorporates moderating and intervening factors shaping this relationship.

ICT diffusion on the insurance

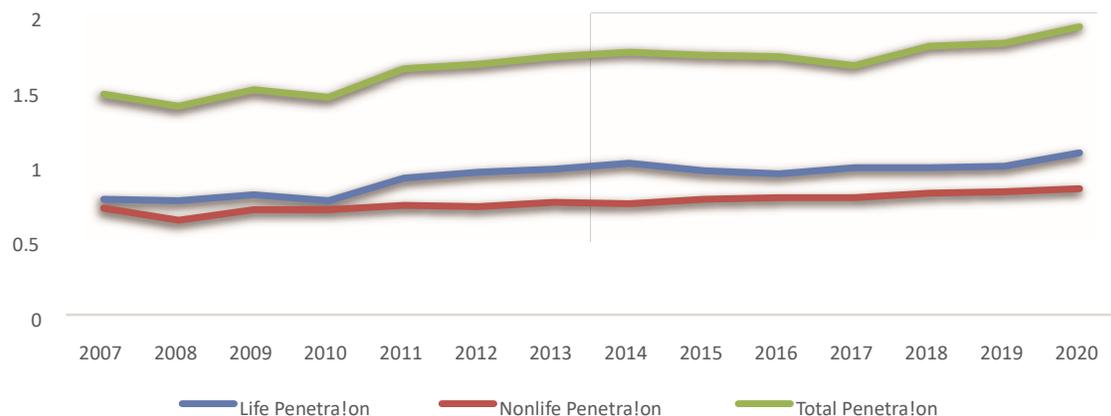The adoption of information and communication technology (ICT) is widely recognized as a critical enabler of insurance market development and its contribution to economic growth. Akinlo (2023) argues that ICT provides insurers with opportunities to innovate, scale operations, and adapt to rapidly changing market conditions, thereby enhancing productivity and growth. Similarly, Ali (2020) contends that ICT adoption,

combined with skilled human resources, can help insurers overcome low penetration rates by facilitating adaptation to technological change. The digital transformation of insurance—often referred to as e-insurance—has redefined service delivery through online sales platforms, digital marketing, and real-time information exchange, effectively eliminating traditional time and space constraints in insurance provision (Sapa et al., 2014).

Through ICT-enabled platforms, insurers can improve operational efficiency, expand outreach to underserved and rural communities, and design customized insurance products, all of which contribute to higher insurance penetration (Akinlo, 2023). ICT diffusion enhances productivity by streamlining resource allocation, reducing transaction costs, improving technical capabilities, and shifting production frontiers outward (Stroeken, 2001). Moreover, digital tools enable insurers to collect and analyze customer data more effectively, improving relationship management, fraud detection, risk assessment, and pricing accuracy (Bazini & Madani, 2015; Asongu & Odhiambo, 2019). These efficiency gains ultimately strengthen insurance performance and its growth-enhancing effects (Chatterjee, 2020).

Empirical evidence supports the role of ICT as a catalyst in the insurance–growth nexus. Zhang et al. (2022) show that ICT diffusion—particularly through mobile transactions and internet use—enhances insurance uptake and health outcomes, implying broader economic benefits. Salatin et al. (2014) similarly highlight that ICT adoption improves production capacity, task specialization, service quality, and speed within the insurance industry. In the SSA context, Sibindi (2022) finds that ICT indicators such as fixed telephone lines, mobile subscriptions, and broadband penetration positively influence life insurance market development. Consistently, Asongu and Odhiambo (2019) advocate for ICT-friendly policies, noting that broadband and mobile penetration significantly support insurance development.

Overall, while the individual relationships between ICT and growth, as well as insurance and growth, are well documented, the persistence of low insurance penetration in SSA suggests that these linkages are incomplete when examined in isolation. The existing literature largely overlooks how ICT diffusion conditions or reinforces the impact of insurance market development on economic growth. This gap motivates further empirical inquiry into the moderating or intervening role of ICT diffusion in the insurance–growth relationship, particularly in regions such as SSA where technological transformation remains uneven.

Figure 1. Trend analysis of insurance variables, 2007–2020.

The persistent need for insurance market development in Sub-Saharan Africa (SSA) has intensified interest in examining the combined effects of information and communication technology (ICT) diffusion and insurance on economic growth. Accordingly, this study contends that ICT diffusion constitutes a critical mechanism through which insurance markets can be strengthened to stimulate economic growth. On this basis, the study investigates the moderating role of ICT diffusion in the insurance–growth nexus in SSA. As illustrated in Figure 1, insurance penetration indicators exhibit an upward trend across SSA between 2007 and 2020. The OECD (2017) reports that both life and nonlife insurance segments possess substantial growth potential, largely due to their persistently low penetration relative to the size of SSA economies. Consequently, the future expansion of insurance markets and gross premium volumes is expected to depend strongly on prevailing economic conditions, financial development, and the extent of ICT diffusion across the region.
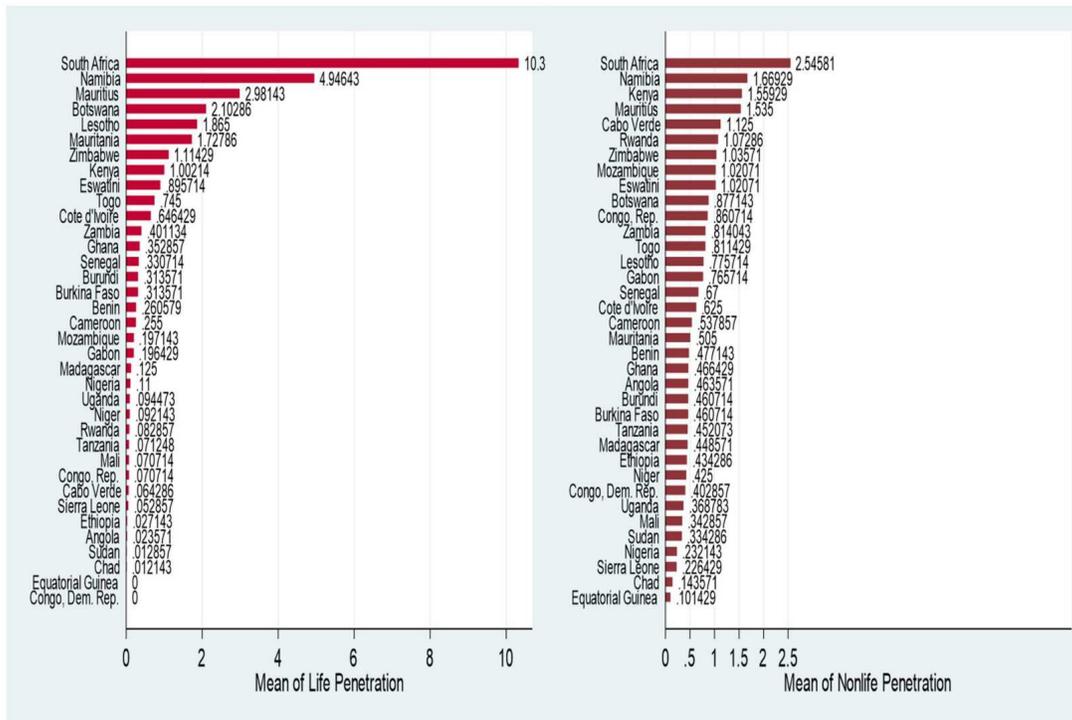
Figure 2. Average values of life and nonlife penetration, 2007–2020.

Such developments may therefore be expected (Benlagha & Hemrit, 2020). Figures 2 and 3 provide a graphical illustration of insurance penetration and GDP across countries, highlighting substantial cross-country heterogeneity. A closer examination of the data reveals that insurance penetration remains relatively low and warrants greater policy attention. In particular, Figure 3 demonstrates persistently low levels of total insurance penetration across the sample countries.
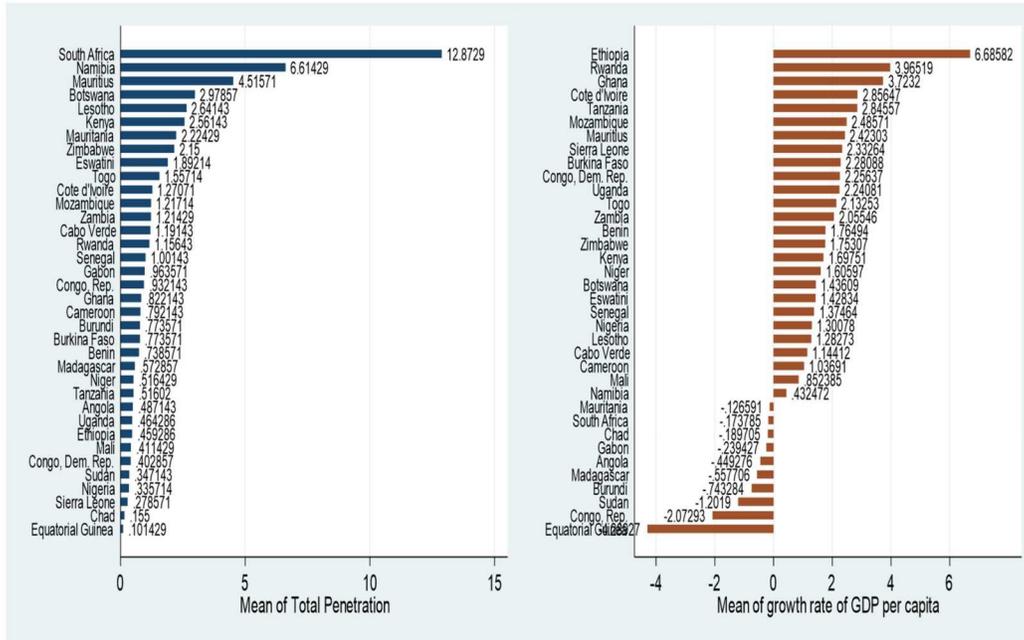
Figure 3. Average values of total penetration and growth rate of GDP per capita, 2007–2020.
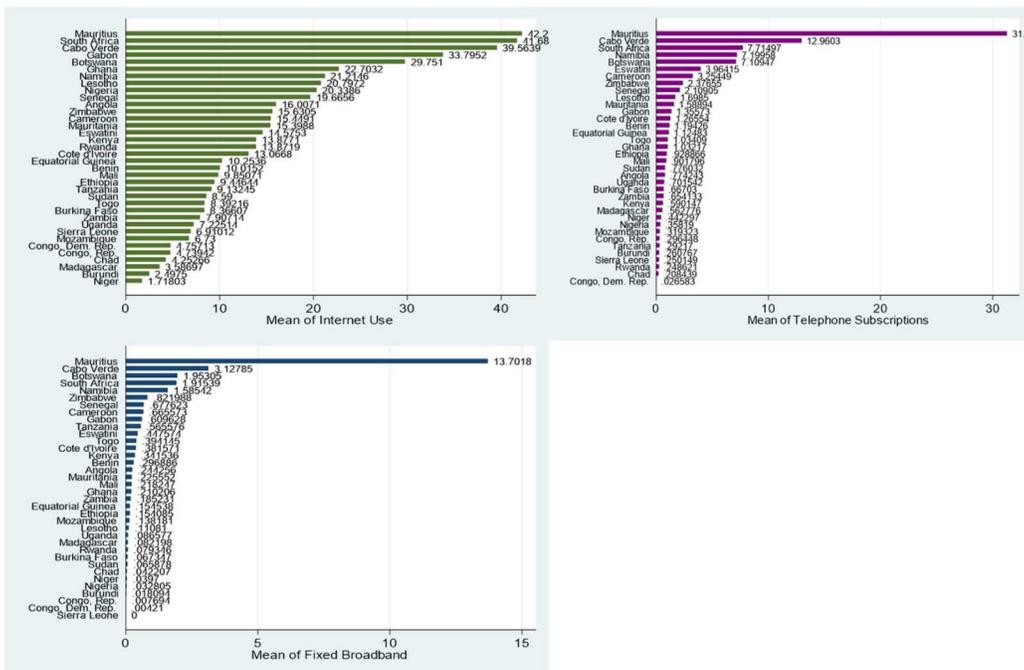
Figure 4. Average values if ICT diffusion variables, 2007–2020.

These low levels are evident across SSA countries and are further reflected in the life and nonlife insurance penetration trends shown in Figure 2 over the sample period. This pattern indicates substantial untapped potential that could be leveraged to strengthen insurance market development and, in turn, support economic growth. Consistent with the literature, ICT diffusion emerges as a critical enabler of insurance market expansion. Figure 4 provides encouraging evidence for SSA, showing that rising fixed

broadband subscriptions, telephone penetration, and internet usage—particularly in countries such as Mauritius, Cabo Verde, South Africa, Namibia, and Botswana—create favorable conditions for digital transformation and insurance market development. At the same time, Figure 3 highlights pronounced disparities in GDP per capita growth across SSA, with countries such as Ethiopia, Rwanda, Ghana, and Côte d'Ivoire performing relatively well, while others, including Equatorial Guinea, Congo Republic, Sudan, Burundi, and Madagascar, lag behind. These disparities suggest that coordinated development of ICT infrastructure and insurance markets could play a meaningful role in accelerating economic growth across the region. Although insurance penetration and ICT diffusion remain relatively low in several SSA countries, both sectors are expanding (Ofori et al., 2022), indicating that ICT diffusion offers viable opportunities to deepen insurance markets and enhance long-term economic growth.

Data and preliminary analysis

This study examines the synergistic effects of ICT diffusion and insurance market development on economic growth using panel data from 36 Sub-Saharan African (SSA) countries over the period 2007–2020. The conceptual framework illustrating the hypothesized relationships is presented in Figure 5. Consistent with prior empirical studies, economic growth is primarily proxied by the growth rate of GDP per capita, which reflects both income dynamics and overall economic performance (Cheng et al., 2021; Levendis & Lee, 2013; Nguyen & Doytch, 2022). This indicator is measured as the annual percentage change in GDP per capita for country i (i = 1, 2, …, N) at time t (t = 1, 2, …, T). To ensure robustness, the study also employs aggregate GDP growth as an alternative measure, defined as the annual percentage growth of GDP at constant 2015 US dollars, capturing changes in overall economic output and development levels.
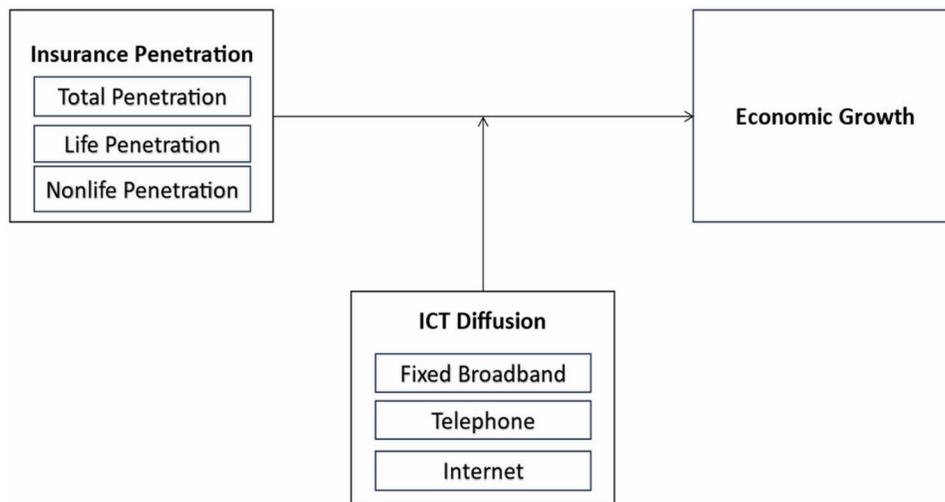
Figure 5. The moderating effect of ICT diffusion on insurance and growth.

Economic growth is further examined through its interaction with insurance market development and ICT diffusion (Asongu & Odhiambo, 2020; Nguyen & Doytch, 2022). Insurance development is proxied by total, life, and nonlife insurance penetration to capture its heterogeneous effects on growth. ICT diffusion is measured using the proportion of internet users, fixed broadband subscriptions, and telephone subscriptions, in line with established studies (Appiah-Otoo & Song, 2021; Ofori et al., 2022; Zhang et al., 2022). To control for macroeconomic and structural factors, inflation, foreign direct investment, and urbanization are included to reflect macroeconomic stability, economic openness, and population concentration, respectively (Akinlo, 2015; Ofori et al., 2022). All data are sourced from the World

Development Indicators (WDI) database, except insurance indicators, which are obtained from the Swiss Re Sigma database. This data selection follows prior empirical work examining telecommunications and economic growth (Levendis & Lee, 2013).

Table 1 summarizes variable definitions, while Table 2 reports pairwise correlations. The mean GDP per capita growth rate is 1.26%, with substantial variability ranging from −22.312% to 18.06% over the sample period, reflecting heterogeneous growth experiences across SSA countries. Insurance penetration remains relatively low, with average total, life, and nonlife penetration rates of 1.61%, 0.88%, and 0.72%, respectively, suggesting limited insurance market development in the region. ICT diffusion indicators also show modest averages, with fixed broadband, telephone subscriptions, and internet usage recorded at 0.82, 2.71, and 14.83, respectively. Additionally, average foreign direct investment and inflation rates are 4.19 and 142.39, while urbanization averages 41.1%, highlighting structural and macroeconomic diversity across the sample.

Following Appiah-Otoo and Song (2021), Roger et al. (2022), and Ofori et al. (2022), this study constructs an ICT diffusion index using three indicators: internet usage, fixed broadband subscriptions, and telephone subscriptions. To aggregate these indicators into a composite measure, Principal Component Analysis (PCA) is employed. PCA is a robust dimensionality-reduction technique that preserves the underlying information content of correlated variables while condensing them into a smaller set of principal components (Greenacre et al., 2022).

The suitability of PCA depends on the strength of intercorrelations among the variables and sample adequacy. These conditions are satisfied, as evidenced by the high pairwise correlations among the ICT indicators reported in Table 2, confirming the appropriateness of PCA for index construction. The PCA results are presented in Table A1 (Appendix A), while the associated eigenvectors are reported in Table A2. In addition, the Kaiser–Meyer–Olkin (KMO) statistics, which assess sampling adequacy through total and partial correlations among indicators, are reported in Table A1. KMO values exceeding the threshold of 0.5 indicate that the sample is adequate for PCA-based index construction.

Table 1. Descriptive statistics of variables.

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
GDPPCg	GDP per capita growth (annual %)	504	1.260	4.495	−22.312	18.066
GDP growth	GDP growth (annual %)	504	3.800	4.725	−20.599	20.715
Total	Ratio of total insurance premium volume to GDP	504	1.608	2.367	0.013	14.897
Life	Ratio of life insurance premium volume to GDP	504	0.886	1.929	0.012	11.677
Nonlife	Ratio of nonlife insurance premium volume to GDP	504	0.724	0.549	0.001	3.200
Fixed broadband	Fixed broadband subscriptions (per 100 people)	504	0.824	2.626	0.000	25.413
Telephone	Fixed telephone subscriptions (per 100 people)	504	2.709	5.590	0.000	37.641
Internet	Individuals using the internet (% of population)	504	14.833	15.511	0.000	70.000
ICT Diffusion	Calculated via PCA	504	0.072	0.148	0.000	1.000

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
FDI	Foreign direct investment, net inflows (% of GDP)	504	4.198	5.819	−11.199	39.811
Inflation	Consumer price index (2010 = 100)	503	142.395	202.067	59.044	3364.8
Urbanization	Urban population (% of total population)	504	41.100	17.390	9.864	90.092

Table 2. Correlation Analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) CO2pc	1.000											
(2) GDPpc	0.389***	1.000										
(3) ICT index	0.085***	0.487***	1.000									
(4) Trade	−0.077***	−0.011	0.172***	1.000								
(5) Urban	0.223***	0.407***	0.389***	−0.076***	1.000							
(6) Energy	0.565***	0.357***	0.325***	−0.033	0.211***	1.000						
(7) Financial	0.080***	0.436***	0.400***	−0.085***	0.335***	0.185***	1.000					
(8) Institution	−0.005	0.128***	0.235***	−0.085***	0.400***	−0.021	0.085***	1.000				
(9) Education	−0.028	0.053*	0.085***	0.016	0.330***	−0.017	0.053*	0.135***	1.000			
(10) Population	−0.170***	−0.072**	−0.065**	−0.072**	−0.210***	−0.211***	−0.085***	−0.085***	−0.015	1.000		
(11) Inflation	−0.024	−0.027	−0.055*	0.017	−0.085***	−0.017	−0.055*	−0.015	−0.015	0.027	1.000	
(12) FDI	−0.028	−0.027	−0.055*	0.017	−0.085***	−0.017	−0.055*	−0.015	−0.015	0.027	0.027	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

The ICT diffusion index is found to be adequate for empirical analysis. The overall Kaiser–Meyer–Olkin (KMO) statistic of 0.621 confirms sufficient sampling adequacy of the ICT covariates. The scree plot, together with the Kaiser criterion (eigenvalue ≥ 1), is presented in Figure 6 and indicates the extraction of a single component. Specifically, the first factor records an eigenvalue of 2.46 and explains approximately 75% of the total variance, justifying its retention for index construction. To ensure interpretability and minimize redundancy among factor loadings, an orthogonal varimax rotation (Kaiser normalization off) is applied. The ICT diffusion index is subsequently derived by aggregating the weighted contributions of each underlying variable to the retained factor and then normalized to lie between 0 and 1. The normalization procedure is expressed as follows:

$$STIit = (Xit − Xmin)/(Xmax − Xmin) \qquad (1)$$

Such that Xmax and Xmin represents the maximum and minimum values of the initial index for the respective countries across the years; Xit represents the value of the initial index. As a result, the normalized indicators range between 0 and 1. Hence, the higher the ICT index, the higher the diffusion of information and communication technology and vice versa.

Empirical strategy

This study employs the Generalized Method of Moments (GMM) estimator developed by Arellano and Bond (1991) to examine the relationship between insurance market development, ICT diffusion, and economic growth in Sub-Saharan Africa (SSA). GMM is preferred because it effectively addresses potential endogeneity arising from reverse causality, omitted variables, and measurement errors by exploiting the dynamic structure of panel data and controlling for unobserved country-specific effects (Arellano & Bover, 1995). Endogeneity concerns are particularly relevant due to the inclusion of the lagged dependent variable and the possible simultaneity between economic growth and insurance penetration, as growth may both influence and be influenced by insurance development (Alhassan, 2016; Asongu & Odhiambo, 2020; Singhal et al., 2022). In addition, GMM is suitable for this study given that the cross-sectional dimension (N) exceeds the time dimension (T) and performs well in relatively small samples (Levendis & Lee, 2013).

Given these advantages, the study adopts the two-step system GMM estimator, which improves efficiency and reduces finite-sample bias, particularly when instruments are weak (Blundell & Bond, 1998; Das et al., 2018). Internally generated instruments are employed to correct for endogeneity following Arellano and Bond (1991) and related empirical studies (Horvey et al., 2023). Specifically, two lags of the explanatory variables are used as instruments in the first-difference equation, while one lag of the first difference is employed as an instrument in the level equation. The empirical model is specified as:

$$GDP_{it} = b1 GDP_{it-1} + b2 INS_{it} + b3 ICT_{it} + b4(INS*ICT)_{it} + b5 FDI_{it} + b6 INF_{it} + b7 URB_{it} + m_i + \partial_t + 1_{it} \quad (2)$$

Where: GDP represents GDP per capita; GDP_{it-1} represents the one-period lag of the dependent variable; INS represents insurance penetration variables (i.e. total, life and nonlife penetration); ICT represents ICT diffusion variables and its index; INS*ICT represents the interaction between insurance penetration and ICT diffusion; FDI represents foreign direct investment; INF represents inflation rate; URB represents urbanization; β represents the parameters to be estimated; m_i represents the unobserved country-specific fixed effects; ∂_t represents the time fixed-effect and 1_{it} is the idiosyncratic error term.

With respect to the interaction between insurance penetration and ICT, the study follows the conditions specified by Brambor et al. (2006) to test for the joint significance of the constitutive and interaction terms to arrive at the net effect of insurance penetration and ICT diffusion on economic growth. The net effect was derived by taking the first derivative of the constitutive and interactive terms with respect to insurance penetration

Finally, the reliability of the GMM estimates is evaluated using several post-estimation diagnostics. Hansen's test of over-identifying restrictions is employed to assess instrument validity, with failure to reject the null hypothesis indicating appropriate instruments (Horvey et al., 2023). Additional checks include tests for first- and second-order serial correlation, the statistical significance of interaction terms, and ensuring that the number of instruments does not exceed the number of cross-sectional units.

3. Result and Discussion

The empirical analysis begins with the baseline estimations reported in Table 3, where Models (1)–(7) examine the unconditional effects of insurance market development and ICT diffusion—captured by the ICT index, fixed broadband, telephone, and internet usage—on economic growth. Subsequently, the study evaluates the intervening role of ICT diffusion in the insurance–growth relationship. Table 4 presents the

joint effect of total insurance penetration and ICT diffusion on economic growth, while Tables 5 and 6 extend the analysis to disaggregated insurance measures (life and nonlife penetration) and their interaction with ICT diffusion, as reported in Models (8)–(11). All estimated models satisfy standard GMM validity requirements. Specifically, the absence of second-order serial correlation is confirmed by the insignificance of the AR(2) statistics, while the Hansen test of over-identifying restrictions remains insignificant, validating the choice of instruments. In addition, the lagged dependent variable (GDP per capita growth) is positive and statistically significant, confirming the dynamic specification of the model and indicating persistence in economic growth, whereby countries with higher initial GDP per capita tend to grow faster than those with lower levels.

Table 3. The baseline results of insurance penetration, ICT and economic growth in SSA (Dependent Variable: GDP per capita).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L.GDP	1.788***	1.748***	1.840***	0.289***	0.293***	0.309***	0.319***
	(0.356)	(0.350)	(0.386)	(0.071)	(0.067)	(0.073)	(0.108)
FDI	0.161	0.174*	0.109	0.590	0.593**	0.748**	0.703
	(0.098)	(0.096)	(0.157)	(0.371)	(0.275)	(0.361)	(0.571)
Inflation	0.008**	0.00**	0.004	0.017	0.016*	0.020*	0.014
	(0.003)	(0.003)	(0.006)	(0.011)	(0.009)	(0.012)	(0.012)
Urbanization	−0.120	−0.121	−0.062	−0.438	−0.450*	−0.555*	−0.541
	(0.084)	(0.077)	(0.150)	(0.326)	(0.231)	(0.286)	(0.409)
Total Penetration	0.993						
	(0.569)						
Life Penetration		1.262*					
		(0.636)					
Nonlife Penetration			1.086				
			(3.809)				
ICT Diffusions				2.145**			
				(1.061)			
Telephone					0.232		
					(0.269)		
Fixed broadband						0.746**	
						(0.479)	
Internet							0.106*
							(0.161)
Country and Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	467	467	467	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of groups	36	36	36	36	36	36	36
Number of instruments	11	11	11	11	11	11	11
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000	0.012
AR(2)	0.467	0.474	0.438	0.804	0.769	0.982	0.737

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hansen *p*-value	0.165	0.167	0.144	0.709	0.710	0.758	0.690

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

The baseline results in Table 3 focus on the direct effects of ICT diffusion and insurance market development (total, life, and nonlife) on economic growth. The estimates reported in columns (4)–(7) reveal a positive and significant relationship between ICT diffusion and economic growth. In particular, the ICT index exhibits a statistically significant growth-enhancing effect, underscoring the critical role of ICT in fostering economic performance. This finding aligns with earlier empirical evidence emphasizing the importance of ICT in developing and emerging economies (Benlagha & Hemrit, 2020; Chatterjee, 2020; Das et al., 2018). Consistent with Appiah-Otoo and Song (2021), the results suggest that ICT diffusion enhances productive capacity across economic sectors, strengthens global economic integration, and improves competitiveness, thereby contributing meaningfully to sustained economic growth.

Table 4. Results on the moderating role of ICT on the relationship between total penetration and economic growth in SSA (Dependent Variable: GDP per capita).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	1.418***	1.411***	1.618***	1.326***
	(0.237)	(0.290)	(0.336)	(0.159)
Total Penetration	0.763	0.457	0.272	0.303
	(0.584)	(0.374)	(0.248)	(0.493)
FDI	0.169**	0.143	0.173**	0.066*
	(0.079)	(0.087)	(0.081)	(0.095)
Inflation	0.008**	0.006**	0.007**	0.004
	(0.004)	(0.003)	(0.003)	(0.003)
Urbanization	−0.109*	−0.101	−0.112*	−0.054
	(0.070)	(0.068)	(0.064)	(0.091)
ICT Diffusion	−0.611**			
	(0.032)			
Total Penetration*ICT Diffusion	3.131***			
	(1.058)			
Fixed broadband		−1.629***		
		(0.501)		
Total Penetration*Fixed broadband		0.366***		
		(0.123)		
Telephone			−0.920***	
			(0.311)	
Total Penetration*Telephone			0.189***	
			(0.068)	
Internet				−0.064***
				(0.015)
Total Penetration*Internet				0.018*
				(0.011)
Net Effects	0.988**	0.758**	0.783**	0.422*

Variables	(8)	(9)	(10)	(11)
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
Countries	36	36	36	36
No. of Instruments	12	12	12	12
AR(1)	0.000	0.001	0.002	0.001
AR(2)	0.578	0.576	0.522	0.516
Hansen P-value	0.186	0.157	0.183	0.134

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

The estimated coefficients for internet usage, telephone subscriptions, and fixed broadband access are positive, indicating that ICT diffusion through these channels promotes economic growth in Sub-Saharan Africa (SSA). This finding corroborates earlier studies suggesting that ICT diffusion enhances economic performance by fostering innovation and technological advancement (Awad & Albaity, 2022; Jayaprakash & Pillai, 2022). ICT enables firms to automate processes, streamline operations, and improve productivity through the adoption of digital tools, software applications, and internet-based platforms. Moreover, the expansion of e-commerce, digital platforms, and online marketplaces facilitated by ICT creates new business opportunities and market access, ultimately leading to higher output and sustained economic growth (Odhiambo, 2022). These results underscore the importance of policy initiatives aimed at improving ICT access, usage, and digital skills across SSA economies.

The results in columns (1)–(3) further indicate that insurance market development—covering total, life, and nonlife insurance—exerts a positive effect on economic growth, although the coefficients are largely statistically insignificant, except for life insurance, which exhibits marginal significance at the 10% level. The positive association can be attributed to the risk-transfer role of insurance, which enhances financial stability and boosts confidence among households, firms, and governments. By mitigating uncertainty, insurance encourages investment and supports the expansion of economic activities. This finding aligns with the extant literature emphasizing that insurance contributes to economic growth through risk reduction, investment promotion, improved risk management, and enhanced financial stability (Balcilar et al., 2020; Sawadogo et al., 2018).

Table 5. Results on the moderating role of ICT on the relationship between life penetration and economic growth in SSA (Dependent Variable: GDP per capita).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	1.557***	1.523***	1.546***	1.344***
	(0.216)	(0.284)	(0.325)	(0.157)
Life Penetration	0.411	0.559	0.435	0.454
	(0.312)	(0.414)	(0.306)	(0.626)
FDI	0.179**	0.133*	0.182**	0.077
	(0.084)	(0.074)	(0.081)	(0.106)
Inflation	0.005**	0.006**	0.007**	0.004
	(0.003)	(0.002)	(0.003)	(0.003)
Urbanization	−0.121*	−0.091	−0.118*	−0.060
	(0.078)	(0.064)	(0.063)	(0.095)

Variables	(8)	(9)	(10)	(11)
ICT Diffusion	−0.711**			
	(0.382)			
Life Penetration*ICT Diffusion	2.123***			
	(0.428)			
Fixed broadband		−0.916***		
		(0.211)		
Life Penetration*Fixed broadband		1.314***		
		(0.079)		
Telephone			−0.617***	
			(0.199)	
Life Penetration*Telephone			0.189***	
			(0.064)	
Internet				−0.056***
				(0.013)
Life Penetration*Internet				0.008
				(0.005)
Net Effects	0.563**	0.817*	0.947***	0.572
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
Countries	36	36	36	36
No. of Instruments	12	12	12	12
AR(1)	0.000	0.001	0.001	0.000
AR(2)	0.567	0.522	0.535	0.511
Hansen *P*-value	0.123	0.173	0.183	0.137

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

Insurance penetration contributes positively to economic growth in Sub-Saharan Africa (SSA), encompassing both life and nonlife insurance markets (Apergis & Poufinas, 2020). Life insurance supports long-term investment, financial stability, and human capital development through education and skills formation, all of which are essential for sustained growth. In addition, life insurance policies can serve as collateral for credit, easing access to finance and stimulating entrepreneurship and business expansion (Alhassan & Fiador, 2014). Nonlife insurance, on the other hand, mitigates risks related to property damage, accidents, and natural disasters, thereby encouraging investment in riskier but productive ventures. By transferring risk to insurers, firms can operate with greater confidence, enhancing resilience and business continuity and fostering economic activity (Horvey et al., 2023).

Despite these positive channels, the largely insignificant coefficients suggest that insurance development alone is insufficient to drive economic growth in SSA. This finding supports PwC (2018), which argues that improving insurance penetration in Africa requires complementary structural reforms and technological advancement. Against this backdrop, the study proceeds to examine whether ICT diffusion strengthens the growth-enhancing role of insurance. Accordingly, Tables 4–6 assess the joint effect of insurance penetration and ICT diffusion on economic growth by incorporating both constitutive and interaction terms, following the approach of Brambor et al. (2006).

Table 6. Results on the moderating role of ICT on the relationship between nonlife penetration and economic growth in SSA (Dependent Variable: GDP per capita).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	0.827***	1.666***	0.776	1.237***
	(0.227)	(0.355)	(0.826)	(0.421)
Nonlife Penetration	3.467	2.361	5.445	−1.644
	(2.424)	(1.992)	(4.490)	(2.310)
FDI	0.234	0.084	−0.235	0.053
	(0.313)	(0.073)	(0.352)	(0.212)
Inflation	0.020*	0.006*	−0.017	−0.001
	(0.010)	(0.003)	(0.010)	(0.008)
Urbanization	0.268	−0.075	0.274	0.027
	(0.210)	(0.075)	(0.208)	(0.178)
ICT Diffusion	−0.754*			
	(0.342)			
Non-life Penetration*ICT Diffusion	3.103**			
	(1.491)			
Fixed broadband		−1.231		
		(0.763)		
Non-life Penetration*Fixed broadband		0.596*		
		(0.443)		
Telephone			2.634	
			(2.041)	
Nonlife Penetration*Telephone			−1.613	
			(1.228)	
Internet				−0.074
				(0.071)
Nonlife Penetration*Internet				0.032
				(0.101)
Net Effects	3.690**	2.852*	1.075	−1.169
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
Countries	36	36	36	36
No. of Instruments	12	12	12	12
AR(1)	0.000	0.000	0.017	0.011
AR(2)	0.521	0.489	0.502	0.507
Hansen *P*-value	0.245	0.161	0.092	0.067

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

The estimated results in Model (8) reveal that the ICT diffusion index significantly and positively moderates the relationship between total insurance penetration and economic growth in Sub-Saharan Africa (SSA). This finding is robust across different insurance penetration measures, indicating that ICT

diffusion is a critical enabler in strengthening the growth-enhancing role of the insurance market. The result supports Sibindi (2022), who argues that ICT adoption improves insurance market efficiency through product innovation, efficient service delivery, fraud detection, and enhanced information dissemination. By reducing processing time for policy approval and claims settlement and expanding access through digital platforms, ICT stimulates insurance penetration and, ultimately, economic growth (PwC, 2018; Asongu et al., 2020).

Further evidence from the computed net effects confirms that while insurance penetration alone is insufficient to drive growth, its interaction with ICT diffusion yields a significantly positive impact on economic performance. This underscores the complementarity effect of ICT diffusion—through access, usage, and digital skills—in amplifying the contribution of insurance to growth. Disaggregated results show that fixed broadband and telephone subscriptions significantly enhance the growth effects of total and life insurance penetration, while fixed broadband also strengthens the nonlife insurance–growth nexus. Although internet usage exhibits weaker and partly insignificant interactions, this may reflect constraints such as limited market size and poor connectivity in SSA (Benlagha & Hemrit, 2020; Akinlo, 2023). Overall, the findings demonstrate that ICT infrastructure is a necessary condition for unlocking the growth potential of the insurance sector. In line with neoclassical growth theory, technology improves productivity and simplifies processes, making insurers more effective contributors to economic growth (Masenyetse & Manamathela, 2023). Consequently, governments should prioritize policies that promote ICT access, usage, and skills, while insurers must adapt business models to ongoing technological change to fully harness the insurance–growth synergy in SSA.

Table 7. The baseline results of insurance penetration, ICT and economic growth in SSA (Dependent Variable: GDP growth).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lag of GDP	1.539***	1.463***	1.900***	1.781***	1.891***	1.739***	1.200**
	(0.407)	(0.379)	(0.425)	(0.265)	(0.398)	(0.391)	(0.525)
FDI	0.601	0.611*	0.232*	0.213*	0.227**	0.229*	0.095
	(0.370)	(0.345)	(0.120)	(0.198)	(0.102)	(0.134)	(0.113)
Inflation	0.022**	0.021**	0.011*	0.014**	0.011**	0.012**	0.002
	(0.011)	(0.009)	(0.005)	(0.006)	(0.004)	(0.005)	(0.005)
Urbanization	−0.495*	−0.470*	−0.194	−0.183*	−0.162*	−0.174*	−0.041
	(0.277)	(0.245)	(0.118)	(0.091)	(0.081)	(0.095)	(0.109)
Total penetration	3.819**						
	(1.880)						
Life penetration		4.466*					
		(1.983)					
Nonlife Penetration			5.849				
			(3.225)				
ICT Diffusion				2.994**			
				(1.328)			
Fixed broadband						0.204**	
						(0.165)	
Telephone							0.080
							(0.097)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Internet							−0.039
							(0.046)
Country and Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	467	467	467	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000
No. of groups	36	36	36	36	36	36	36
No. of instruments	11	11	11	11	11	11	11
AR(1)	0.008	0.005	0.001	0.000	0.000	0.000	0.005
AR(2)	0.828	0.782	0.428	0.417	0.383	0.433	0.460
Hansen p-value	0.118	0.138	0.115	0.318	0.286	0.154	0.649

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

Although the literature reports mixed evidence on the inflation–growth nexus, this study suggests that moderate inflation can stimulate economic growth by encouraging consumer and firm spending in anticipation of rising prices. Inflation may also enhance government revenue by increasing the nominal value of taxable goods and services without raising statutory tax rates, thereby expanding fiscal space for investment in infrastructure, education, healthcare, and other growth-supporting sectors.

Supplementary analysis further estimates the net effects of ICT diffusion by differentiating Equation (2) with respect to ICT, as reported in Appendix C. The results show predominantly positive net effects for individual ICT variables, although some adverse effects emerge, possibly reflecting weak ICT infrastructure in SSA (Lee et al., 2005). In contrast, the overall ICT diffusion index consistently exhibits positive net effects across all specifications, including life and nonlife insurance models. These findings reinforce the synergistic role of ICT diffusion and insurance market development in driving economic growth. The positive net effects highlight ICT as a critical growth catalyst, fostering innovation, creativity, and the development of new products, services, and business models (Appiah-Otoo & Song, 2021). Consequently, sustained investment in ICT infrastructure remains essential for SSA economies to fully harness digital transformation as a driver of long-term economic growth (Jayaprakash & Pillai, 2022).

Table 8. Results on the moderating role of ICT on the relationship between total penetration and economic growth in SSA (Dependent Variable: GDP growth).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	1.286***	0.868**	1.275***	1.210***
	(0.313)	(0.345)	(0.375)	(0.359)
Total Penetration	1.349	2.427*	1.358	2.057
	(0.947)	(1.385)	(0.959)	(1.228)
FDI	0.536	0.589*	0.529	0.401
	(0.298)	(0.337)	(0.316)	(0.337)
Inflation	0.022**	0.020**	0.019**	0.016*
	(0.010)	(0.009)	(0.009)	(0.009)
Urbanization	−0.412*	−0.493**	−0.410*	−0.336
	(0.229)	(0.237)	(0.228)	(0.243)

ICT Diffusion	−0.479**			
	(0.201)			
Total Penetration*ICT Diffusion	2.815**			
	(1.382)			
Fixed broadband		−3.933**		
		(1.606)		
Total Penetration*Fixed broadband		0.957**		
		(0.396)		
Telephone			−2.138**	
			(1.041)	
Total Penetration*Telephone			0.473**	
			(0.228)	
Internet				−0.088**
				(0.038)
Total Penetration*Internet				0.021*
				(0.012)
Net Effects	1.552**	3.216**	2.639**	2.368*
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
No. of groups	36	36	36	36
No. of Instruments	12	12	12	12
AR(1)	0.006	0.015	0.007	0.012
AR(2)	0.831	0.884	0.823	0.700
Hansen *P*-value	0.182	0.107	0.117	0.109

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

The results further indicate that insurance moderates ICT dynamics to generate positive synergistic effects on economic growth, confirming a complementary relationship between ICT diffusion and insurance development. Accordingly, strengthening human capital, expanding investment in ICT infrastructure, and promoting industrial development—particularly within the insurance sector—are essential to maximizing these growth-enhancing synergies. To assess the robustness of the baseline results reported in Tables 3–6, this study employs an alternative proxy for economic growth, namely GDP growth, which is widely used in the empirical literature to capture economic development and output performance (Asongu & Odhiambo, 2020; Nguyen & Doytch, 2022). The results presented in Tables 7–10 confirm the persistence of GDP over time. Consistent with the main findings, the interaction between insurance penetration (total, life, and nonlife) and ICT diffusion remains positive and significant. The computed net effects, reported in Appendix B2, further support the conclusion that ICT diffusion amplifies the growth-enhancing impact of insurance development in Sub-Saharan Africa.

The reliability of these findings is reinforced by several diagnostic tests. The Hansen test of over-identifying restrictions confirms the joint validity of the internal instruments and indicates the absence of instrument proliferation. In addition, the insignificant p-values of the AR(2) test suggest no second-order serial correlation in the residuals. Finally, the statistical significance of the Wald test (Prob > F) confirms that the estimated models are correctly specified, thereby affirming the robustness of the empirical results.

Table 9. Results on the moderating role of ICT on the relationship between life penetration and economic growth in SSA (Dependent Variable: GDP growth).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	1.129***	1.117***	1.134***	1.278***
	(0.348)	(0.331)	(0.357)	(0.351)
Life Penetration	2.027	2.942*	1.923	2.616*
	(1.345)	(1.490)	(1.218)	(1.389)
FDI	0.518*	0.543*	0.550*	0.434
	(0.298)	(0.302)	(0.308)	(0.322)
Inflation	0.023**	0.018**	0.018**	0.015*
	(0.010)	(0.008)	(0.008)	(0.008)
Urbanization	−0.439*	−0.426**	−0.420*	−0.341
	(0.219)	(0.207)	(0.220)	(0.225)
ICT Diffusion	−0.915**			
	(0.565)			
Life Penetration*ICT Diffusion	2.949**			
	(1.307)			
Fixed broadband		−0.620**		
		(0.772)		
Life Penetration*Fixed broadband		0.664**		
		(0.299)		
Telephone			−1.326**	
			(0.652)	
Life Penetration*Telephone			0.450**	
			(0.207)	
Internet				−0.060
				(0.039)
Life Penetration*Internet				0.021*
				(0.011)
Net Effects	2.239**	3.489**	3.142**	2.927**
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
No. of groups	36	36	36	36
No. of Instruments	12	12	12	12
AR(1)	0.007	0.006	0.007	0.007
AR(2)	0.831	0.866	0.827	0.656
Hansen P-value	0.123	0.114	0.132	0.075

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

Table 10. Results on the moderating role of ICT on the relationship between nonlife penetration and economic growth in SSA (Dependent Variable: GDP growth).

Variables	(8)	(9)	(10)	(11)
Lag of GDP	1.626***	1.484***	0.614	1.471***
	(0.213)	(0.484)	(0.779)	(0.266)
Nonlife Penetration	1.096	6.311	1.401	0.622
	(0.985)	(5.921)	(5.975)	(1.532)
FDI	0.237	0.170	−0.226	0.135
	(0.157)	(0.246)	(0.375)	(0.116)
Inflation	−0.026*	0.012	−0.023*	0.005
	(0.015)	(0.010)	(0.013)	(0.005)
Urbanization	0.385*	−0.213	0.482*	−0.088
	(0.294)	(0.212)	(0.280)	(0.113)
ICT Diffusion	1.472*			
	(0.785)			
Non-life Penetration*ICT Diffusion	4.825**			
	(2.101)			
Fixed broadband		−2.163		
		(1.444)		
Non-life*Fixed broadband		1.187		
		(0.848)		
Telephone			4.106	
			(2.494)	
Nonlife Penetration*Telephone			−2.494	
			(1.517)	
Internet				−0.107***
				(0.039)
Nonlife Penetration*Internet				0.089
				(0.056)
Net Effects	1.443	7.289	−5.746**	1.942
Country and Time Effects	Yes	Yes	Yes	Yes
Observations	467	467	467	467
Prob > F	0.000	0.000	0.000	0.000
No. of groups	36	36	36	36
No. of instruments	12	12	12	12
AR(1)	0.008	0.008	0.017	0.001
AR(2)	0.475	0.582	0.448	0.451
Hansen p-value	0.257	0.361	0.079	0.047

Note: Standard errors in parentheses, Significant values include: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; FDI represents foreign direct investment; GDP represents gross domestic product.

4. Conclusions and Implications

Information and communication technology (ICT) plays a pivotal role in promoting financial and economic growth and supporting sustainable development. This study contributes to the literature by examining how ICT diffusion enhances insurance market development in driving economic growth in Sub-Saharan Africa (SSA), a region with persistently low insurance penetration. Motivated by Africa's Sustainability Agenda 2030, which positions ICT as a key enabler of development across all sectors, this study employs macro-level data from 36 SSA countries over the period 2007–2020 and applies a dynamic system GMM approach to analyze the joint effects of insurance penetration (total, life, and nonlife) and ICT diffusion, including fixed broadband, telephone, and internet usage.

The findings indicate that insurance penetration alone has a positive but largely insignificant effect on economic growth, reflecting the limited scale and depth of insurance markets in SSA. In contrast, ICT diffusion significantly promotes economic growth and, more importantly, strengthens the insurance–growth relationship. The positive and significant net effects confirm that ICT diffusion moderates and amplifies the contribution of insurance to economic growth, with fixed broadband emerging as a particularly important channel, especially for nonlife insurance. These results suggest that insurance becomes a more effective driver of growth when supported by robust ICT infrastructure. Consequently, policymakers should prioritize investments in affordable ICT infrastructure and digital skills, while insurers should leverage digital platforms and fintech partnerships to expand coverage, improve efficiency, and enhance competitiveness. Despite data limitations, the study underscores the critical complementarity between ICT and insurance in fostering sustainable economic growth in SSA and highlights avenues for future research on inclusive growth and firm-level dynamics.

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