

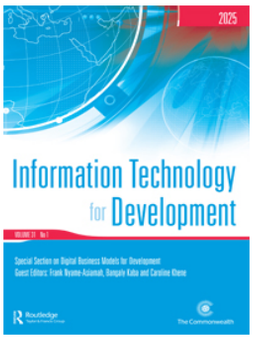
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Towards economic growth in SubSaharan Africa is there a synergy between insurance market development and ICT diffusion

Sylvester Horvey; Jones Odei-Mensah

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Information Technology for Development

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/titd20

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To cite this article: Sylvester Senyo Horvey & Jones Odei-Mensah (2025) Towards economic growth in Sub-Saharan Africa: is there a synergy between insurance market development and ICT diffusion?, Information Technology for Development, 31:1, 178-205, DOI: 10.1080/02681102.2024.2361478

To link to this article: https://doi.org/10.1080/02681102.2024.2361478

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Published online: 04 Jun 2024.

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INFORMATION TECHNOLOGY FOR DEVELOPMENT
2025, VOL. 31, NO. 1, 178–205
https://doi.org/10.1080/02681102.2024.2361478

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ABSTRACT

This study contributes to the literature by investigating the intervening role of information and communication technology (ICT) diffusion on insurance and economic growth in Sub-Saharan Africa (SSA). This study uses the generalized method of moments technique based on 36 countries, spanning 2007–2020. First, the empirical findings reveal that insurance penetration (i.e. total, life and nonlife) and ICT diffusion induce economic growth in SSA. Second, the evidence suggests that ICT boosts the role of insurance in affecting economic growth. Third, the individual ICT variables such as fixed broadband, telephone and internet propel the impact of total and life penetration on growth. Additionally, fixed broadband was remarkable in enhancing the effect of nonlife penetration on growth. The findings imply that though insurance enhances economic growth, its impact is more revealing through the intervening role of ICT infrastructure. Therefore, insurers must embrace technology and leverage ICT development to improve their performance on growth.

KEYWORDS

Insurance; economic growth; ICT diffusion; Sub-Saharan Africa

SUBJECT CLASSIFICATION CODES

G22; O4; C3

1. Introduction

Information and communication technology (ICT) is essential for business and economic development (Jayaprakash & Pillai, 2022). ICT assists in fostering development by offering new markets, increasing competitiveness, and improving access to knowledge and skills when used to solve local conditions and unique problems (Qureshi, 2011). As a result, ICT has indeed become indispensable in our daily lives. Individuals use the internet to communicate, network and do business. The use of ICT further presents a comprehensive set of contemporary assets through which individuals and organizations create opportunities (Ofori et al., 2022; Raifu et al., 2023). In Sub-Saharan Africa (SSA), many countries have begun to recognize the transformative power of technology; hence, various initiatives and digital agendas on ICT and technological advancement are on the increase. Some of these digital efforts include the use of Mobile Midwives in Ghana and Nigeria, M-Pesa, which is active in eight different African nations, and more. These efforts align with Africa's Sustainable Development Agenda 2030, which features ICT as the backbone for sustainable development

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John Levendis is the accepting Associate Editor for this paper.

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on the continent (Sustainable Development Goal Centre, SDGC, 2017). Thus, the 2030 agenda encompasses increased levels of technology, including wireless mobile phones, broadband internet, and computer and network hardware infrastructure. More so, to develop the digital landscape on the continent, SSA countries are developing ties with many global players such as China and the European Union to develop ICT infrastructure, boost digital skills and encourage innovation among businesses and societies (Abimbola et al., 2021).

According to SDGC (2017), rapid growth in ICT will result in institutional, social, financial and economic development. The importance of ICT is further accentuated by the COVID-19 pandemic, which undoubtedly revealed technology as a significant channel for transacting business. As a result, the adoption of ICT, particularly in using mobile phones and internet connectivity in SSA, has improved significantly. This has revolutionized several businesses, including the insurance industry, which is a key driver of economic growth and development. This is because insurers provide financial security and stability to people and businesses against various losses or damages (Horvey et al., 2024). Notwithstanding, SSA's insurance penetration level (2%) remains the lowest globally. To ensure the development of the insurance market, there is a need to find novel ways to enhance its operational framework to guarantee better service delivery, more accessibility to financial services, and effective intermediation. ICT offers the insurance industry a variety of ways to adapt and innovate in the face of the fast-changing environment. For instance, ICT diffusion provides digital platforms for insurers to communicate and sell insurance products. PwC (2018) adds that the use of ICT offers accessibility to new insurance clients at a lower cost and helps to analyze behavioral data to create unique, more suitable insurance products, which will ultimately ensure insurance market development in SSA. ICT also leads to product innovation and service delivery, which eventually drives the insurance industry. Despite the importance of ICT, developing countries trail behind developed countries when it comes to employing ICT to satisfy consumer and market expectations in a manner that complies with international standards (Aguegboh et al., 2023). The relatively low level of ICT use in developing countries, which substantially impacts economic growth and development, contributes to several insurance system inefficiencies.

In this regard, the question remains: how does ICT reinforce the development of insurance in affecting economic growth in SSA? We focus on this question against the backdrop that insurers can leverage ICT to facilitate smooth bill settlements, implement digital insurance, provide quick responses to customers, create and preserve jobs, and access general information. Asongu and Odhiambo (2019) add that adopting ICT is vital to insurance development as it promotes information sharing. Sibindi (2022) further highlight that ICT infrastructure enables the insurer to serve the insured in various ways more effectively. First, there is a significant reduction in the lead times between insurance applications and coverage approval. Second, the insured can now submit their claim swiftly, using, for example, email, which can significantly shorten the period between filing a claim and its settlement. Moreover, as insurance becomes available online, the insured can keep track of their benefits. Hence, Witherspoon (2015) suggests that insurance companies must adapt their business practices to the constant technological change they face, particularly in the ICT sector. Since the acceptance and assimilation of ICT are recognized as a crucial part of the development equation, these changes may become substantial dangers if neglected, but they may very well become lucrative opportunities if anticipated and effectively implemented.

Given the above argument, this study posits that ICT diffusion is critical to the performance and development of the insurance industry. It not only adds value to the industry but also influences its future with changing times and requirements. Asongu et al. (2020) support this assertion by explaining that ICT improves the insurance industry's institutional dimensions and operational activities. These have an impact on everything from underwriting decisions to claim settlements. Several studies have highlighted the importance of ICT on economic development (Appiah-Otoo & Song, 2021; Chatterjee, 2020; Jayaprakash & Pillai, 2022), arguing that ICT addresses economic and social problems. However, other scholars criticize ICT as insufficient for development because technology alone does not suffice. Lee et al. (2005) add that poor ICT infrastructure contributes

to its insignificant impact. Another group of scholars have also given much credence to the importance of insurance on economic growth and development (Balcilar et al., 2020; Olayungbo & Akinlo, 2016; Pradhan et al., 2016), while a more recent study examined the impact of insurance on inclusive growth (Horvey et al., 2023). These studies present that insurance supports growth by reducing risks, promoting investment, providing risk management services and enhancing financial stability. Despite this evidence, there is still a lack of substantive research on the potential impact of ICT on insurance market development and its role in fostering growth. Although studies such as Asongu and Odhiambo (2019), Asongu et al. (2020) and Akinlo (2023) have investigated the relationship between ICT, governance, and insurance in Africa, they failed to look into how ICT diffusion moderates the insurance-growth relationship. On this note, this study extends this line of enquiry by examining the moderating role of ICT diffusion on insurance market development and economic growth.

As PwC (2018) suggests, to ensure the development of the insurance market and its impact on economic growth, the industry needs to innovate by scaling up its technological setup to target the underinsured. This demands the use of digital platforms for the insurance business. This will help insurers provide a more digital experience to their clients, which will enhance the low penetration rate crippling the insurance industry in SSA, thereby promoting economic growth. This is very important given that the SSA insurance industry records low levels of insurance uptake and remains the most underdeveloped across the continent. This could be attributed to several factors, such as political instability, economic crises, lack of technological development and the recent COVID-19 pandemic, which have slowed economic and insurance market development (PwC, 2018). Further, the insurance industry in SSA accounts for only 2% of its contribution to the gross domestic product (GDP), although it is home to about 15% of the world's population. The African Insurance Organisation (AIO) (2019) asserts that the low insurance penetration presents tremendous growth potential in SSA. One of the ways to develop the sector is through ICT (Akinlo, 2023). Hence, the growth of the insurance industry will be a reality when insurers leverage ICT diffusion to enhance their penetration levels. Consequently, we argue that the propelling effect of insurance market development on economic growth is contingent on ICT diffusion in SSA.

Our study contributes to the scholarly literature and policymaking in several ways. First, this study adds to the literature by examining the relationship between ICT, insurance market development and economic growth. In this light, we explore the intervening role of ICT diffusion between insurance market development and growth in SSA, which has the lowest insurance penetration worldwide. Second, we provide segregated analysis for total penetration and life and nonlife penetration. This is due to the difference in business operations of the life and nonlife markets. For example, life insurance companies sell long-term insurance policies such as health, life and funeral insurance, whereas the nonlife sector mostly sells short-term policies such as business, fire and property insurance (Horvey & Odei-Mensah, 2024). This also impacts the nature of their investment preferences. Due to the differences in their activities and risks, the effect of ICT on each sector's development may differ (Akinlo, 2023). Hence, this technique helps to identify how ICT diffusion drives the development of these industries and whether the joint effect of ICT diffusion with life and nonlife penetration remains the same as total penetration. Third, the study serves as a policy tool for regulators to design policies to improve ICT adoption and usage within the industry. This will be beneficial in developing the insurance market. In line with Africa's sustainable development agenda 2030, governments will be informed about the policies needed to drive ICT access, usage and skills in SSA to ensure its impact on financial and economic development.

The remainder of the paper follows this order: the next section reviews the theoretical underpinnings and the empirical literature on insurance, ICT diffusion and economic growth. The subsequent section deals with the methodology, while the fourth section presents the analysis and discussion of the findings. The final section concludes and provides policy recommendations.

2. Literature

2.1. Theoretical underpinning

Globalization and the need for integrated growth-promoting policies have increased the importance of social, financial, and economic development (Qureshi, 2015). This suggests a connection between ICT, insurance market development and economic growth. This is consistent with neoclassical information diffusion models (Kwan & Chiu, 2015; Asongu & Odhiambo, 2019). According to the literature, neoclassical growth models are consistent with the importance of information technology as a source of financial and economic development in developing countries (Solow, 1999; Bernard & Jones, 1996; Asongu et al., 2019). As a result, the neoclassical theory acknowledges that technological advancement is vital for economic growth. Additionally, the neoclassical theory highlights that technology is essential for firm growth as it improves productivity and simplifies processes (Masenyetse & Manamathela, 2023). Hence, the use of technology in various sectors of the economy, including insurance, enhances business operations, efficient communication, innovation and increased productivity, which drives economic growth (Jarraya et al., 2023). Furthermore, according to the theoretical underpinnings, technology improves macroeconomic development and citizens' livelihoods (Asongu et al., 2019). Insurance development is one of these outcomes (Asongu & Odhiambo, 2019). This is affirmed by the OECD (2017), which states that technological change is vital in determining a transformation in the financial sector and, by extension, efficiency gains in the insurance market. These arguments align with the Sustainable Livelihood Approach (SLA), which explains that economic agents/industries can create transformative opportunities if they have access to assets such as ICT. On this note, the SLA incorporates ICTs into the framework to ensure flexibility and opportunities for growth (Duncombe, 2006). This is very important because ICT diffusion can be used to achieve operational efficiency in settings such as the SSA, where administrative and structural inefficiencies impede financial development and its growth-lubricating effects. Also, ICT tools such as mobile phones and the internet may empower individuals, improve market accessibility, aid in skill development, fortify social capital, and increase adaptive capacity – all of which are critical components in creating sustainable livelihoods and promoting industrial and economic growth.

2.2. Review of ICT diffusion-growth nexus

ICT diffusion is seen as an important driver of the economy in developed and developing countries. ICT contributes to economic development through innovations in new products, processes, and company models (Jayaprakash & Pillai, 2022). ICT lowers operational costs, accelerates revenue development, and gives firms a competitive edge in the market, which has fundamentally changed how organizations operate. Chatterjee (2020) adds that ICT reduces user costs because of the lower transaction cost associated with better communication and encourages innovation and the development of new products and methods. This leads to business, financial and economic development. This argument is also affirmed by Qureshi and Najjar (2017), who state that investment in ICT infrastructure leads to economic growth.

Several studies have explored the nexus between ICT and growth (Appiah-Otoo & Song, 2021; Awad & Albaity, 2022; Benlagha & Hemrit, 2020; Chatterjee, 2020; Das et al., 2018). However, some research has indicated a modest effect, while others have not identified a statistically significant effect. For example, Das et al. (2018) found a significant positive relationship between ICT and growth in SSA, and the interaction between ICT and financial development was positive. Similarly, Appiah-Otoo and Song (2021) indicate that ICT (i.e. mobile, internet, and fixed-band) influences the growth of rich and poor countries. However, poor countries gain more from the evolution of ICT. More so, Lee et al. (2005) find that ICT investment only stimulates growth in developed countries and attribute this to the low level of ICT infrastructure in developing nations. Further, Röller and

Waverman (2001) explored a sample of OECD and developing countries and revealed that ICT will only significantly impact growth beyond a certain threshold level. Gheraia et al. (2022) found a positive relationship and further explained that ICT diffusion has an increased indirect effect on financial development and economic growth. Awad and Albaity (2022) extend this line of enquiry to explore the mechanisms through which ICT determines growth. They found that education, openness, and domestic investment are essential factors for enhancing ICT development and growth. They further reveal that ICT leads to social improvement due to its significant impact on human capital. This aligns with Qureshi's (2015) argument that ICT for development improves people's lives, particularly the poor, by giving them access, usage and skills. Asongu et al. (2020) examined how information technology moderates governance and growth and revealed that information technology promotes governance dynamics by affecting growth.

2.3. Review of insurance and economic growth

The debate between insurance market development and economic growth has received great attention in the literature. Scholars argue that insurance positively impacts economic growth, which is further explained by the supply-leading hypothesis, indicating that a country's economic performance is largely influenced by its growth (Pradhan et al., 2016). Advocates of this theory suggest that the development of the insurance industry could accelerate economic growth by promoting financial asset savings, thereby boosting capital formation and GDP (Alhassan & Fiador, 2014).

Empirical literature supports this argument. For instance, Sawadogo et al. (2018) investigated the effect of life insurance on economic growth and concluded that the development of the life insurance industry considerably boosts economic growth. This aligns with Akinlo and Apanisile (2014), who also found a positive relationship, explaining that a well-developed insurance market is essential for economic growth, as it offers long-term investments for economic growth while enhancing one's capacity for risk-taking. Further, Apergis and Poufinas (2020) discovered that the coefficient of insurance penetration is positively and significantly associated with economic growth before and after the global financial crisis (2007–2008). The results remained the same for the life and nonlife sectors. This underscores the insurance industry's resilience, which maintains a positive impact across different periods of events. Balcilar et al. (2020) support this argument by narrating that the insurance market's activities can impact economic growth through risk pooling, financial intermediation, indemnity against losses, fund mobilization, and investment opportunities. Contrarily, Lee et al. (2016) found an inverse relationship between insurance and growth and attributed this to an unhealthy institutional environment.

Further analysis performed by Balcilar et al. (2020) found evidence supporting short-run and long-run effects on the insurance-growth nexus. This implies the immediate and sustained effect of insurance on growth. However, Olayungbo and Akinlo (2016) found diverse results, indicating short-run negative and long-run positive effects for Kenya, Mauritius and South Africa. Similarly, Alhassan and Fiador (2014) found a long-run positive relationship between insurance and growth, suggesting that mobilized funds from insurers have long-run effects on growth. In another study, Akinlo (2015) explored the causality between insurance and economic growth in 30 SSA countries, revealing a bidirectional causality, indicating homogeneity across the countries studied. On the other hand, Okonkwo and Eche (2019) found a unidirectional relationship among the BRICS economies between 1990 and 2014. They further explain that the relationship is country-specific and dependent on several institutional and economic factors.

The vast body of the literature suggests that insurance plays a significant role in economic growth since it is the primary resource for risk management for businesses and individuals. Nevertheless, the mixed findings from the literature suggest that the insurance-growth relationship has not been fully exhausted. As Asongu and Odhiambo (2020) indicate, examining the direct relationship between insurance and growth is not enough. Hence, there is a need for more empirical work to explore the specific factors that are likely to influence this relationship.

2.4. ICT diffusion on the insurance-growth nexus

Akinlo (2023) posits that one of the key enablers for the development of the insurance market is the adoption of ICT. ICT offers tremendous opportunities for insurers to innovate and scale up their operations to respond to the fast-changing environment, thereby affecting economic growth. Ali (2020) supports this argument and suggests that leveraging ICT development and appropriate resource personnel can help insurance overcome low penetration issues, requiring adaptation to technological changes in the insurance market. Again, the digital revolution led by ICT has brought different ways of doing business in the insurance industry. One of these is digital insurance, also known as 'E-insurance,' which explains insurance services that offer online insurance sales, services, and information sites. This includes producing and delivering insurance services through digital means (Sapa et al., 2014). This defies the limitation of time and space in selling insurance products. These days, individuals use the internet to search for insurance-related information. Insurance companies also use this platform to advertise and sell insurance products. Hence, insurance companies can boost product demand by utilizing technology to connect with rural communities, develop new products, and quickly promote products, making ICT infrastructure crucial for insurance assessment in all economies (Akinlo, 2023).

In this regard, insurers may increase productivity, deliver better client services, and expand into new areas by leveraging ICT tools and methods. This will lead to an improvement in insurance performance, leading to economic growth. Asongu and Odhiambo (2019) add that ICT diffusion provides insurers with growth potential, including adopting new service delivery techniques and improved fraud detection and data collection opportunities that can result in better risk mitigation strategies. According to Stroeken (2001), ICT enhances development and productivity by streamlining resource allocation, reducing transaction costs, enhancing technical capabilities, and facilitating an outward shift in production functions. Bazini and Madani (2015) explain that insurers can gain valuable insights into customers' preferences and expectations by gaining a deeper understanding of their choices and expectations. Therefore, ICT advancements offer fresh approaches to relationship management for insurers.

Efficiency gain is one advantage of ICT in corporate operations (Chatterjee, 2020). Insurers can restructure their operations, reduce expenses, and improve client services using ICT. This can result in a higher penetration of insurance. Zhang et al. (2022) examined the effect of ICT diffusion on health outcomes and found that using mobile phones for monetary transactions and the internet improves health and insurance outcomes. They argue that ICT diffusion enhances investment in insurance, such as buying medical insurance and improving an individual's health outcome. Their findings, therefore, conclude that ICT-driven strategies geared towards improving public health and insurance will lead to economic growth. Salatin et al. (2014) align with this argument by narrating that using ICT in the insurance sector will lead to increased production capacity, specialization of tasks, and improved service quality and speed. Also, the ability of the insurance industry to underwrite risks, determine premium costs and estimate damages can all be enhanced by technology. Developing software and databases to store data and facilitate decision-making regarding customer and insurance business operations can also boost information management (Akinlo, 2023). This will enhance insurance penetration, thereby affecting growth. Sibindi (2022) found that ICT adoption variables, including fixed telephone, mobile cellular subscriptions, and fixed broadband, positively correlate with life insurance market development in 31 SSA countries. This aligns with Asongu and Odhiambo (2019), who suggest that governments in SSA should implement ICT-friendly policies to foster the insurance market, as fixed broadband subscriptions and mobile phone penetration positively affect insurance development.

From the discussion in this section, it can be noted that the relationship between ICT and economic growth has been well explored. Scholars have also provided an understanding of the importance of insurance development to growth. Despite the various studies on the insurance-growth nexus, the penetration rate in SSA remains the lowest globally. Recent developments in ICT and

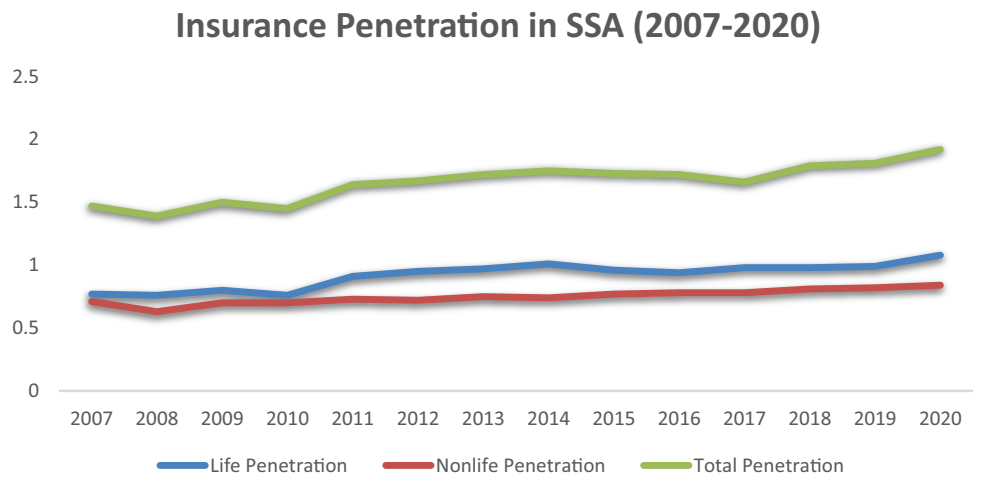


Figure 1. Trend analysis of insurance variables, 2007–2020.

the need for insurance market development in SSA have provoked the need to explore the joint effect of ICT and insurance on economic growth. Hence, this study argues that ICT diffusion can be used to develop the insurance market and drive economic growth. On this note, this study explores the moderating role of ICT diffusion on the insurance-growth nexus in SSA. The results in Figure 1 show rising trends of insurance penetration variables in SSA between 2007 and 2020. According to the 2017 OECD report, life and nonlife insurance have more growth potential due to their low penetration levels compared to the size of each economy. Accordingly, depending on the economic and financial environment, future growth of the insurance market and gross premiums

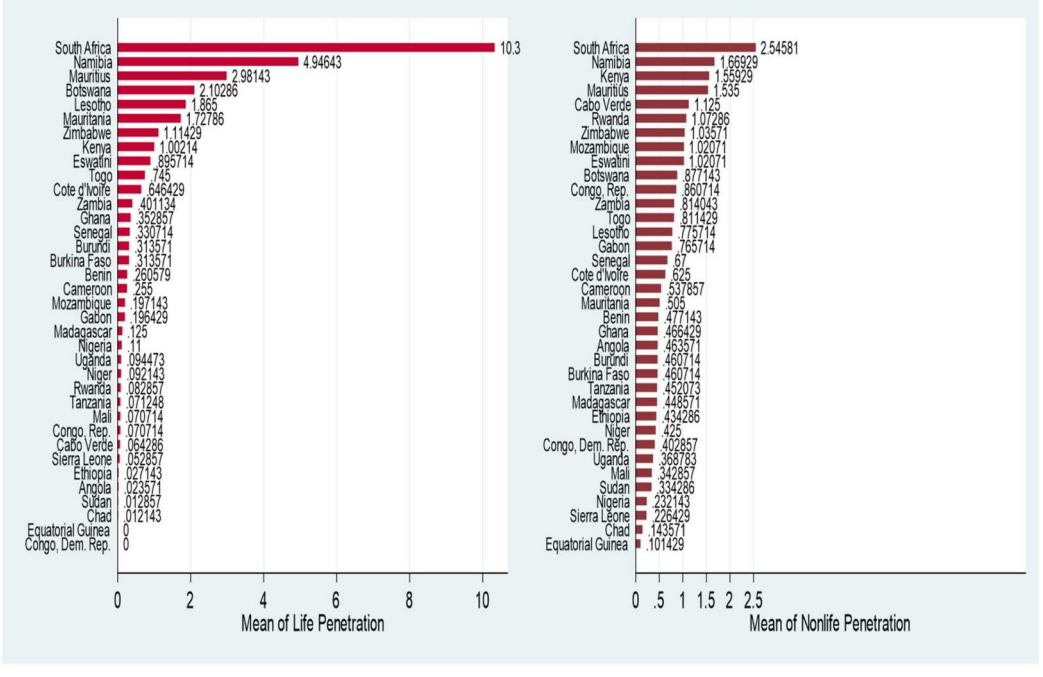


Figure 2. Average values of life and nonlife penetration, 2007–2020.

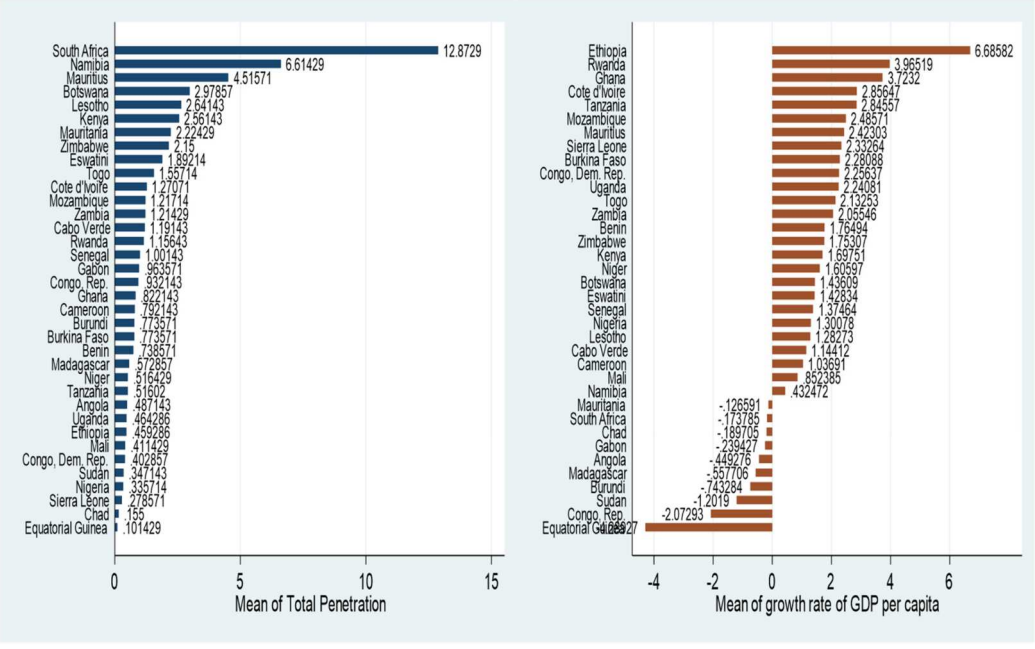


Figure 3. Average values of total penetration and growth rate of GDP per capita, 2007–2020.

may be anticipated (Benlagha & Hemrit, 2020). Figures 2 and 3 present a pictorial view of insurance and GDP, showing cross-country variability. Perusing the data further, we find that insurance penetration requires more attention. For instance, Figure 3 records low total insurance penetration

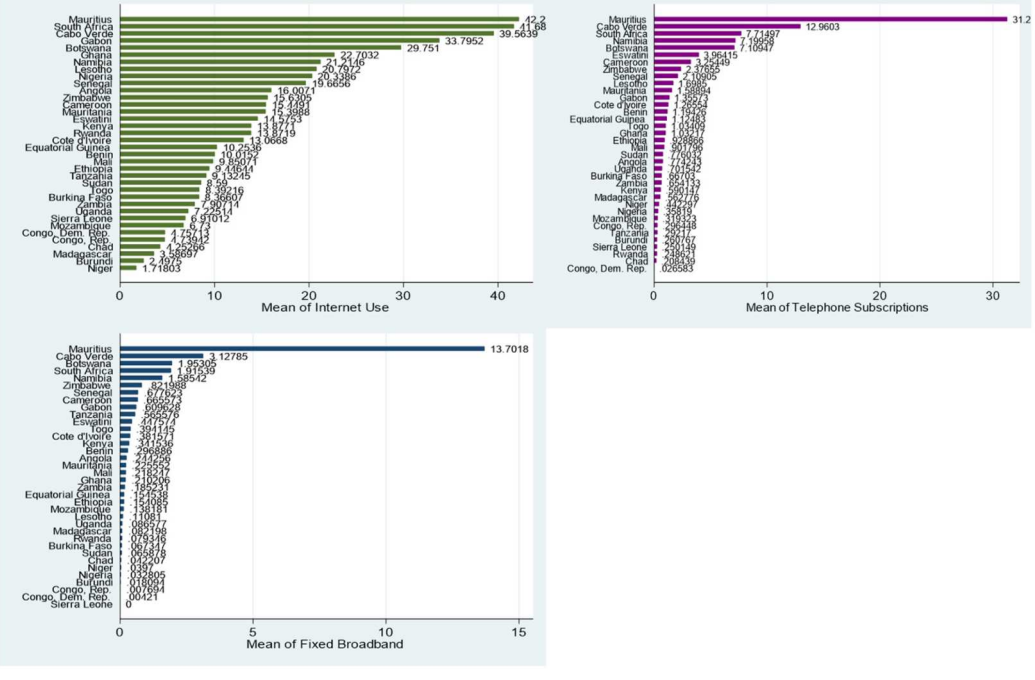


Figure 4. Average values if ICT diffusion variables, 2007–2020.

levels among SSA countries. This is further illustrated in the life and nonlife penetrations in Figure 2, based on the sample period. This signifies substantial unmet gaps that could be harnessed to develop the insurance market to boost growth. As the literature suggests, ICT diffusion is crucial to developing the insurance market. The results in Figure 4 offer glimmers of hope in SSA in enhancing insurance penetration through ICT diffusion. The springing up of Fixed broadband, Telephone subscriptions and internet use in the region, markedly in countries such as Mauritius, Cabo Verde, South Africa, Namibia and Botswana, present opportunities for digital transformation in SSA, which can, in turn, ensure the development of insurance business. Also, there is great variability in GDP per capita growth among SSA countries, as illustrated in Figure 3, with countries such as Ethiopia, Rwanda, Ghana, and Cote d'Ivoire ranking favorably and the lags in the growth rate of GDP per capita in some countries such as Equatorial Guinea, Congo Rep., Sudan, Burundi and Madagascar. This suggests that with appropriate development of the insurance market and ICT, the growth of SSA economies will be achieved. Though insurance and ICT diffusion variables remain low in some countries in SSA, the region's insurance market and ICT infrastructure are growing (Ofori et al., 2022). This suggests that ICT diffusion provides opportunities for insurance market development that can be targeted to enhance economic growth.

3. Method

3.1. Data and preliminary analysis

The study utilizes thirty-six (36) countries from SSA to explore the synergistic relationship between ICT diffusion and insurance market development and their impact on economic growth. This is pictorially illustrated in the conceptual model in Figure 5 to aid the comprehension of the studied relationships. The data covers a 14-year period between 2007 and 2020. This paper aligns with previous studies by measuring economic growth with the growth rate of GDP per capita (Cheng et al., 2021; Levendis & Lee, 2013). This is also an indicator of the income level of an economy (Nguyen & Doytch, 2022) and denotes the annual percentage growth rate of GDP per capita for country i ($i = 1, 2, 3, \ldots N$) and t ($t = 1, 2, 3, \ldots T$). Further, the study recruits GDP growth as an alternative measure of economic growth for robustness analysis. This is measured as GDP growth (annual %) and expressed as the annual growth rate of GDP at market prices expressed in 2015 US dollars, and is used to express the level of economic development or a country's economic output or aggregated

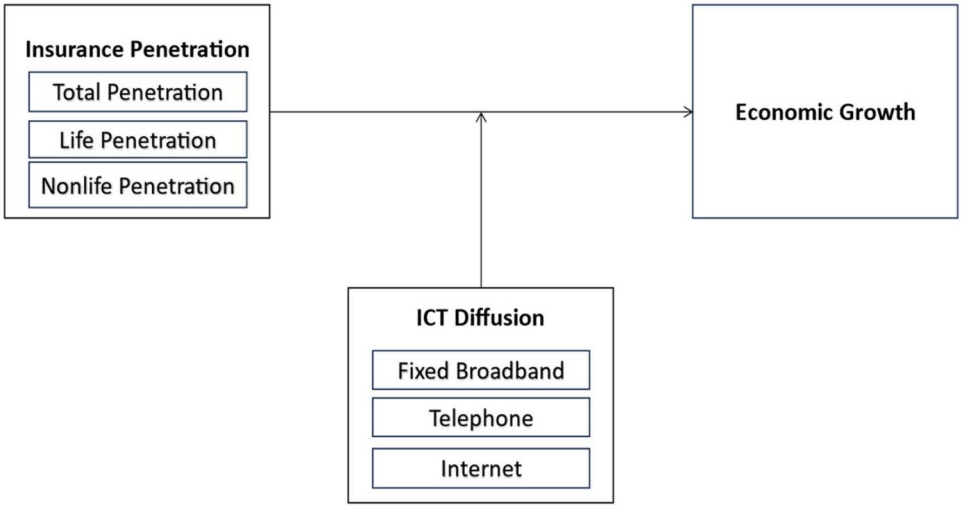


Figure 5. The moderating effect of ICT diffusion on insurance and growth.

growth (Asongu & Odhiambo, 2020; Nguyen & Doytch, 2022). Three proxies, including total penetration, life penetration and nonlife penetration, are used to identify the impact of insurance on economic growth. For ICT diffusion, the study employs the percentage of internet users, fixed broadband, and telephone subscriptions (Appiah-Otoo & Song, 2021; Ofori et al., 2022; Zhang et al., 2022). The study controls for inflation, foreign direct investment and urbanization to capture macroeconomic stability, economic globalization and population density (Akinlo, 2015; Ofori et al., 2022). Data were drawn from the World Development Indicators (WDI) database published by the World Bank for all the variables, except for the insurance variables which were drawn from the Swiss Re Sigma database. The utilization of the data source aligns with Levendis and Lee (2013), who examined the relationship between telecommunications and economic growth.

Table 1 presents the definition and the description of the variables, while information on the pairwise correlation is presented in Table 2. The average value for economic growth, measured by GDP per capita growth, is 1.26. The result shows significant variation, with a minimum value of −22.312 and a maximum value of 18.06 over the study period. The same is true for the insurance penetration variables. The average values of the insurance variables, thus, total, life and nonlife penetration, are 1.61%, 0.88% and 0.72%, respectively, showing low variations as indicated by the standard deviation. The underdeveloped insurance market in SSA may be the reason for the low insurance growth, which is more likely to affect their penetration levels. The estimated averages for ICT diffusion, thus, fixed broadband, telephone and internet users are 0.82, 2.71 and 14.83, respectively. The study also observes average values of foreign direct investment and inflation of 4.19 and 142.39 over the study period. Urbanization also records an average of 41.1.

3.2. Construction of ICT diffusion index

Following the approach by Appiah-Otoo and Song (2021), Roger et al. (2022), and Ofori et al. (2022), this study recruited different variables to create an index for ICT Diffusion. As informed by these studies, we generated the ICT index with the following variables: internet, fixed broadband, and telephone. Again, the study employed the Principal Component Analysis (PCA) to construct the ICT diffusion index. The PCA is a powerful dimensional reduction technique that helps preserve the multi-dimensionality of a set of variables by reducing the number of indices to a smaller set known as principal components (Greenacre et al., 2022). It is significant to highlight that the appropriateness of our dimension reduction (i.e. PCA) for generating the ICT diffusion index depends on the overall correlations and interrelationships between the variables and the adequacy of our sample. This assumption is met in Table 2, which shows high correlations among the ICT covariates, implying that the PCA is appropriate. The results are presented in Table A1 in Appendix A. The corresponding eigenvectors are reported in Table A2. Also, The Kaiser-Meyer-Olkin (KMO) statistics, which display the total and partial intercorrelations between the indicators, are displayed in Table A1. If the KMO statistics are more than 0.5, it implies that the sample size used to calculate the

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
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) GDPPCg	1.000											
(2) GDP growth	0.968***	1.000										
(3) Total	−0.018	−0.107**	1.000									
(4) Life	−0.028	−0.111**	0.988***	1.000								
(5) Nonlife	0.023	−0.074*	0.839***	0.746***	1.000							
(6) Fixed broadband	−0.058	−0.149***	0.291***	0.257***	0.349***	1.000						
(7) Telephone	0.032	−0.091**	0.432***	0.397***	0.470***	0.859***	1.000					
(8) Internet	−0.173***	−0.246***	0.413***	0.397***	0.384***	0.522***	0.461***	1.000				
(9) ICT Index	0.032	−0.091***	0.432***	0.397***	0.470***	0.859***	0.678***	0.461***	1.000			
(10) FDI	−0.010	0.004	−0.054	−0.086**	0.065	−0.049	−0.040	−0.143***	−0.040	1.000		
(11) Inflation	−0.171***	−0.174***	−0.016	−0.030	0.033	−0.011	−0.055	0.132***	−0.055	−0.057	1.000	
(12) Urbanization	−0.213***	−0.207***	0.208***	0.216***	0.137***	0.124***	0.185***	0.450***	0.185***	0.122***	−0.037	1.000

Note: Significant values are in brackets, which includes *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ICT diffusion index is adequate. Given the overall KMO statistics of 0.621, we conclude that our ICT diffusion sample (i.e. the covariates) is adequate and sufficient for empirical analysis. The scree plot, which denotes the number of ICT components and the Kaiser threshold of 1 for selecting components for generating the ICT diffusion index, is reported in Figure 6. One factor was extracted because its eigenvalue was closer to or beyond 1. Factor 1 had an eigenvalue of 2.46 and explained 75% of the overall variance. Individual factors with high factor loadings were minimized using the orthogonal varimax rotation (kaiser off) to determine the contribution of each factor. We then find the total of each underlying variable's contribution to all retained factors to derive the ICT diffusion index. The index was then normalized to lie between 0 and 1. The essence of this approach is to identify countries with high or low ICT diffusion in SSA. Equation (1) describes the normalization process.

$$STI_{it} = (X_{it} - X_{min})/(X_{max} - X_{min}) \tag{1}$$

Such that X_{max} *and* X_{min} represents the maximum and minimum values of the initial index for the respective countries across the years; X_{it} 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.

3.3. Empirical strategy

The study employs the Generalised Method of Moments (GMM) presented by Arellano and Bond (1991) to examine the relationship between insurance market development, ICT diffusion and economic growth in SSA. As Arellano and Bover (1995) reported, GMM is better than other estimators due to its ability to account for any potential endogeneity that might arise from explanatory variables. It also accounts for issues regarding omitted variables and measurement errors by exploiting the data's time series variations and controlling for unobserved country-specific effects. It is important to note that incorporating the lagged term of the dependent variable in the regression model may cause endogeneity problems since the lagged dependent variable depends on the lagged error term, which is a function of the country-specific fixed effects. Another endogeneity concern arises due to the possible simultaneity between GDP and insurance penetration, validating the use of the GMM model. For instance, while the literature argues that insurance affects economic growth, other scholars also suggest that economic growth advances the insurance market (Alhassan, 2016; Asongu & Odhiambo, 2020; Singhal et al., 2022). GMM is employed because it is argued

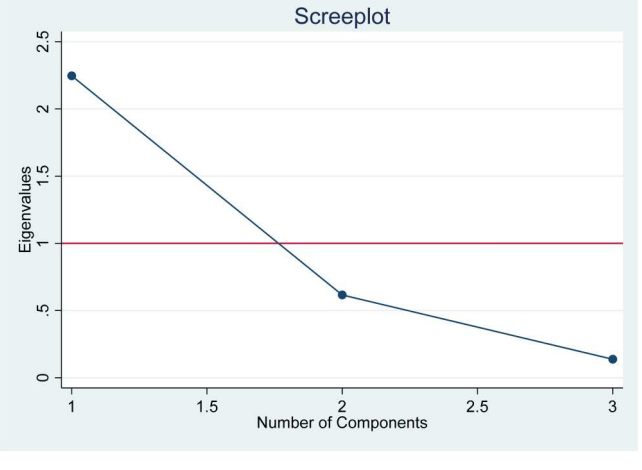


Figure 6. Screeplot of principal components of ICT diffusion index.

that it produces a better-estimated coefficient, especially in a small sample (Levendis & Lee, 2013). Another caveat for choosing GMM is that the number of countries (i.e. N) exceeds the time (i.e. T). Given the benefits of a GMM approach, the system GMM technique, which has better finite sample qualities when the instruments are weak, is employed (Das et al., 2018). In addition, it is more efficient and has a reduced bias. Furthermore, a two-step system GMM is used instead of a one-step system GMM because it can capture issues with omitted variables and measurement errors while controlling for heteroscedasticity and autocorrelation (Blundell & Bond, 1998). In accordance with Arellano and Bond (1991) as well as other published research (such as Horvey et al., 2023), we use internally defined instruments to account for endogeneity. To estimate our models, we employ two lags of our explanatory variables as instruments in the first difference equation, taking into account the possibility that all explanatory variables may be endogenous. Nevertheless, one lag of the first difference of the explanatory variables was used as an instrument for the level equation. As a result, the model is specified as:

$$\begin{aligned} GDP_{it} = & \beta_1 GDP_{it-1} + \beta_2 INS_{it} + \beta_3 ICT_{it} + \beta_4 (INS{*}ICT)_{it} \\ & + \beta_5 FDI_{it} + \beta_6 INF_{it} + \beta_7 URB_{it} + \mu_i + \partial_t + \varepsilon_{it} \end{aligned} \tag{2}$$

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; μ_i represents the unobserved country-specific fixed effects; ∂_t represents the time fixed-effect and ε_{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. As a result, our model is specified as follows:

$$Net\ Effects: \frac{\partial GDP}{\partial INS} = \beta_2 + \beta_4 \mathrm{ICT}_{\mathrm{it}} = 0 \tag{3}$$

Hence, the level of insurance penetration interacted by ICT diffusion is examined by the summation of the coefficients ($\beta_2 + \beta_4$) and the test of the significance of the joint effects.

It is important to note that the effectiveness of the GMM technique in producing reliable estimates depends on several post-estimation checks. We use Hansen's test of over-identification to assess the validity of the instrument in the manner of (Horvey et al., 2023). The Hansen test is based on the null hypothesis that there is no correlation between the detected instruments and the residuals. As a result, the suitability of the instruments and, consequently, the reliability of our estimations depend on the failure to reject the null hypothesis. If the null hypothesis is rejected, the instruments are not robust since the limitations brought about by relying on the instruments are invalid. The validity of our estimates is further assessed using the post-estimation tests for (i) the presence or absence of evidence of first-order or second-order serial correlation in the residuals, (ii) the significance of the interaction terms, and (iii) the number of instruments is less than the number of groups.

4. Results

4.1. Analysis and discussion

This section of the paper presents the interpretation and discussion of the estimated results on the propelling effect of ICT on insurance market development in stimulating economic growth. The

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
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.

analysis begins with the baseline results as shown in Table 3, with Models (1)-(7) providing information on the unconditional effect of insurance market development and ICT diffusion (i.e. ICT index, fixed broadband, telephone and internet) on economic growth. Following this analysis, the intervening role of ICT diffusion on the insurance-growth nexus is tested. Table 4 provides information on the joint effect of total penetration and ICT diffusion on economic growth. Similarly, Tables 5 and 6 focus on the disaggregated variables of insurance penetration (i.e. life and nonlife penetration) and synergy with ICT diffusion on growth. These are presented in Models (8)-(11). All the estimated models are valid, following the validity criteria for assessing GMM models. First, there is the absence of second-order serial correlation in the residuals due to the insignificance of the AR(2) *p*-values. Second, the Hansen test of over-identifying conditions is insignificant, confirming the validity of the instruments. The coefficient value of the lagged dependent (GDP) variable is statistically significant, affirming the regression model's dynamic nature. The results imply that countries with high GDP per capita grow faster than those with low GDP per capita, providing evidence of the persistence of the dependent variable.

As shown in Table 3, the baseline results look at the direct effects of ICT diffusion and insurance market development (i.e. total, life and nonlife) on economic growth. The results in columns (4) to (7) report a positive relationship between ICT and economic growth. The empirical findings provide evidence that the ICT index significantly influences economic growth, showing that ICT is remarkable in fostering economic growth. The result is in line with previous empirical evidence (Benlagha & Hemrit, 2020; Chatterjee, 2020; Das et al., 2018), which establishes the importance of ICT in developing and growing economies. For instance, Appiah-Otoo and Song (2021) demonstrate that ICT fosters growth, which is vital to increasing a nation's capacity for production across all economic sectors, connecting the country to the global economy, and ensuring competitiveness. Also, the coefficient

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*
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.

values for internet, telephone and fixed broadband are positive. This signals that ICT diffusion through the increased use of telephone, fixed broadband, and the internet positively affects economic growth in SSA (Awad & Albaity, 2022). This result appeals to logic as ICT diffusion often drives innovation and technological development (Jayaprakash & Pillai, 2022). Businesses can automate procedures, streamline operations, and increase productivity with the help of technologies like computers, the internet, and software applications. Again, ICT usage fuels the development of digital platforms, e-commerce, and online marketplaces, creating new markets and business prospects. This leads to higher output levels, improved productivity, and economic growth (Odhiambo, 2022). The results suggest that SSA economies should develop policies to encourage ICT access, usage and skills.

The results in columns (1)-(3) further show that insurance, including life and nonlife, positively influences economic growth, although statistically insignificant, except for life insurance, which offers some significance level at 10%. The positive result could be explained by insurance coverage to individuals, organizations and governments. Transferring their risk to insurers ensures financial stability and business confidence. This encourages investment and stimulates growth in economic activities. Scholars present that insurance supports economic growth by reducing risks, promoting investment, providing risk management services and enhancing financial stability (Balcilar et al., 2020). This argument is consistent with the literature (Sawadogo et al., 2018), which suggests that

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)
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 enhances economic growth in SSA, including the life and nonlife insurance markets (Apergis & Poufinas, 2020). For instance, life insurance promotes financial stability, long-term investment, human capital development, and education and skill development, which are crucial for economic growth. Also, policyholders can get credit by using their life insurance policies as collateral for loans (Alhassan & Fiador, 2014). This easy access to financing has the potential to boost entrepreneurship, businesses, and other economic activities, which promote economic growth. Similarly, nonlife insurance provides coverage against risks, including property damage, accidents, and natural disasters, encouraging investment into risky ventures. Businesses may operate more confidently when they transfer part of the risk to insurance providers (Horvey et al., 2023). As a result, this promotes resilience and business continuity, fostering an environment conducive to economic activity. The insignificant results show that insurance alone does not substantially affect economic growth. This evidence supports the claim by PwC (2018), who argue that to enhance insurance penetration in Africa, there must be structural changes and technological advancements on the continent.

We now turn our attention to determining whether ICT diffusion and insurance jointly predict economic growth, as reported in Tables 4–6. This analysis was done by including the constitutive and interaction terms in the same model as Brambor et al. (2006) advised. According to the

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.

estimated results in Model (8), the findings indicate that the overall ICT diffusion index significantly and positively moderates the relationship between total insurance penetration and growth. The results also hold for the different insurance penetration variables, showing statistical significance. This significant positive relationship implies that the presence of ICT diffusion is essential in developing the insurance market, thereby affecting the growth of SSA economies. This aligns with the argument made by Sibindi (2022) that ICT adoption fosters the development of the insurance market in Africa, resulting in increased operational efficiency for insurance. Again, ICT drives the life and nonlife insurance market through product development, efficient delivery, fraud detection, information dissemination and innovativeness. It also provides accessibility to new clients through digital platforms (PwC, 2018). Sibindi (2022) further highlights that ICT infrastructure enables the insurer to serve the insured effectively in various ways. First, there is a significant reduction in the lead times between insurance applications and coverage approval. Second, the insured can now submit their claim swiftly, using, for example, email, which can significantly shorten the period between filing a claim and its settlement. These ICT-inducing measures stimulate insurance growth and development in a country, which will obviously drive economic growth.

Moreover, as insurance becomes available online, the insured can keep track of their benefits. This increases the consumption of insurance products and their penetration level (Asongu et al., 2020), ultimately translating into economic growth. Further, the computed net effect is significantly

positive in all the Tables (see Appendix B1). The positive net effect is equally compelling. While in Table 3, the insurance penetration variables on their own are not enough to spur economic growth, we find evidence in Tables 4–6 that their interaction with ICT diffusion fosters economic growth. This supports the claim that ICT diffusion in the form of access, usage, and skills will boost insurance penetration and affect economic growth in SSA. In this light, the study establishes that ICT diffusion has a coupling effect on insurance (total, life and nonlife) in influencing growth. For instance, ICT tools may expedite and improve the efficiency of life and nonlife insurance operations through underwriting, claims processing, and risk assessment. ICT diffusion ensures easy access to information and the purchase of insurance products, which will likely promote insurance and affect growth. Hence, governments should consolidate ICT adoption policies to foster the insurance market's development and amplify its impact on economic growth.

For the individual ICT diffusion variables, we find that fixed broadband and telephone subscriptions engender significant positive synergies with total penetration and life penetration to foster growth. This suggests that the presence of these factors is essential in driving the insurance industry's effectiveness in affecting growth. This conforms with Asongu and Odhiambo (2020) and Sibindi (2022), who explain that insurance agents can use fixed and mobile telephone systems to great advantage when running a telemarketing campaign to boost insurance sales. Again, voice logging has made it simpler for life insurers to evaluate risks over the phone, eliminating the requirement that the proposer of a life insurance policy fill out a proposal form. Similarly, Table 6 shows that the interaction between fixed broadband and nonlife penetration is significantly positive. However, nonlife penetration presents an insignificant negative joint relationship with telephone subscriptions. Following the same computational procedure in Equation (3), the net effects are calculated as reported in Appendix B1 and presented in the Tables. The result shows the total effect of these variables and reports significant positive values. This evidence supports the notion that Fixed broadband and telephone amplify the effect of insurance on growth. Similarly, the estimated results for internet use also have a positive interaction with the insurance variables. This was significant at 10% for total penetration, while life and nonlife were insignificant. This is consistent with studies on the relationship between ICT and insurance, which failed to find any significant impact (Benlagha & Hemrit, 2020). As Akinlo (2023) explained, small market size and poor internet connectivity may impact internet usage and hinder insurers' adoption of digital technologies.

In summary, the above narrations present that the presence of ICT infrastructure is key to forming relevant synergies with insurance to foster economic growth. Generally, it is clear from the empirical findings that the role of insurance on economic growth is positive but insignificant. However, the relationship is strengthened when moderated by ICT diffusion. The computed net effects affirm the overall impacts of these relationships. The results suggest that ICT diffusion has a complementarity effect on the insurance-growth relationship. Hence, the uniqueness of this finding is that in the presence of ICT diffusion, the insurance industry becomes more effective in driving growth. This corroborates with the neoclassical theory, highlighting that technology is essential for firm growth as it improves productivity and simplifies processes (Masenyetse & Manamathela, 2023). As a result, insurers that embrace ICT are more likely to achieve higher growth, which will lead to the overall growth of an economy. Therefore, governments in SSA should implement policies to promote ICT access, usage and skills. The results further imply that insurance companies must adapt their business practices to the constant technological change, particularly in the ICT sector. This calls for further scrutiny regarding the extent to which policymakers should improve ICT infrastructure in SSA to drive the insurance market to enhance growth.

For our control variables, the estimated results show that foreign direct investment positively impacts economic growth, whereas urbanization presents mixed findings. This inflow of cash can be used to fund new projects, grow current businesses, and boost economic activity. Thus, additional investment might lead to the creation of jobs, the improvement of infrastructure, and an increase in production capacity, all of which could promote economic growth. Inflation also exhibits a positive

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)	
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.

relationship. Though the literature reveals mixed findings on the relationship between inflation and economic growth, we argue that inflation can stimulate consumer and organizational spending in anticipation of rising prices, which can lead to economic growth. Without overtly raising tax rates, inflation can increase government tax receipts. Price increases result in an increase in the nominal value of taxable goods and services, which boosts tax revenue. With this additional revenue, governments can invest in public infrastructure, education, healthcare, and other fields that support long-term economic growth.

The study provided further supplementary analysis by estimating the net effects of ICT diffusion by differentiating Equation (2) with respect to ICT, as evidenced in Appendix C. The essence is to gain a comprehensive understanding of the total effect of ICT on economic growth. The results for the individual ICT variables show positive net effects, while in some cases, adverse net effects were recorded, which might be due to the poor ICT infrastructure in SSA (Lee et al., 2005). Turning to the overall ICT index, the result shows positive net effects, revealing the importance of ICT to SSA's economy. The positive net effects of the ICT index further affirm the synergistic relationship between ICT and insurance, which catalyzes economic growth. This remains consistent with the life and nonlife tables. The positive net effect underscores the vital role of ICT in economic growth. This is not surprising given that the dynamic nature of ICT promotes innovation and creativity, and organizations can leverage this as a springboard for sustained economic growth. More so, ICT encourages the development of new goods, services, and business strategies, which in turn drives economic growth (Appiah-Otoo & Song, 2021). Hence, continuous investment in ICT infrastructure is essential as our digital landscape keeps evolving. Stakeholders can harness its potential to foster economic growth (Jayaprakash & Pillai, 2022). The net

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.

effects further indicate that insurance modulates ICT dynamics to engender positive synergy effects on economic growth. This affirms the synergistic-complementarity relationship between ICT and insurance. Hence, there is a need for human capital development, investment in ICT resources and industrial development, such as insurance.

4.2. Robustness checks

In checking for the robustness of our estimates in Tables 3–6, we use another proxy for economic growth – GDP growth. Empirical literature often uses this to explain the level of economic development or a country's economic output (Asongu & Odhiambo, 2020; Nguyen & Doytch, 2022). The findings in the Tables (see Tables 7–10) explain the persistence of GDP over time. Similar to the results in Tables 4–6, insurance penetration (total, life and nonlife) and ICT Diffusion interaction confirm a positive result. This is further supported by the positive net effects, as presented in Appendix B2. This upholds our results that ICT diffusion amplifies the impact of insurance on the growth of economies in SSA. The reliability of the results is backed by several estimations. The Hansen test for over-identifying restrictions confirms the joint validity of the model's internal instruments, indicating no instrument proliferation. Furthermore, the absence of second-order serial correlation in the residuals, as evidenced by the insignificant *p*-values, reaffirms the robustness of the findings. The significance of the Wald statistics (Prob > F) confirms that all our models have been correctly

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.

specified and reliable for examining the linkages between insurance, ICT diffusion and economic growth.

5. Conclusion and policy recommendations

ICT is an important factor contributing to financial and economic growth, reinforcing sustainable development. This study contributes to the scholarly literature on ICT, insurance and growth by investigating how ICT diffusion improves the insurance market in propelling economic growth in SSA, which, to the best of our knowledge, has received less attention. This study is further motivated by Africa's Sustainability Agenda 2030, which presents ICT as the backbone for sustainable development in the region. According to the Sustainable Development Goal Centre for Africa, ICT affects all sectors of Africa's economy, including the insurance industry. Inspired by this call, we investigate the potential joint effects of insurance penetration (i.e. total, life and nonlife) and ICT diffusion, including its sub-components (i.e. fixed broadband, telephone and internet) on economic growth in SSA countries. This was done by employing the dynamic system GMM technique and macro data of 36 SSA countries, spanning 2007–2020.

First, our baseline results show that insurance positively impacts economic growth in SSA but was mostly insignificant except for life penetration, which was significant at 10%. This suggests that the

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.

current level of insurance in SSA is not potent enough to induce economic growth across the region. This is due to the region's small market size and low penetration levels. Second, the findings further show that ICT diffusion, fixed broadband, telephone subscription, and internet use significantly impact economic growth. Telephone subscription was also positive but insignificant. Third, our results indicate that ICT diffusion significantly moderates the relationship between insurance and economic growth. This is consistent with the disaggregated insurance variables, thus life and nonlife insurance penetrations. The significant positive values of the net effects affirm the intervening role of ICT in insurance market development and economic growth. Further, vis-à-vis fixed broadband, telephone and internet, total and life insurance penetration positively and significantly influence economic growth. This implies that insurance penetration coupled with ICT diffusion can be a game changer in boosting economic growth in SSA. For nonlife penetration, fixed broadband presents a significant moderating influence. The other factors were also positive but insignificant. Our results are robust to several specifications from the dynamic system GMM technique and show that though insurance enhances economic growth, its effect is remarkable in the presence of a strong ICT infrastructure. Hence, ICT can offer significant growth opportunities to SSA countries that are interested in developing their insurance market and economy.

The findings present several implications for both academics and policymakers. Governments in SSA must consider the critical role of ICT and initiate policies to boost ICT resources due to its

significant impact on SSA economies. Such policies could be channeled towards ICT resources such as fixed broadband, internet, and telephone subscriptions. This should be provided at low prices to encourage people to start paying attention to it. Again, governments must consider their economic and infrastructural environment before implementing ICT as it influences the success of ICT initiatives. Considering the region's low insurance penetration level, there is a need to encourage insurers to invest more in ICT infrastructure since it enhances the insurance market. This will provide resilience and improve their global competitiveness. Also, the insurance industry could leverage ICT infrastructure in SSA to strengthen its market development by digitalizing insurance activities and partnering with fintech companies that sell insurance products. This will assist the sector in attracting more customers online and fully utilizing current information technology. This could enhance the demand for insurance products, boost the insurance market, and affect economic growth. Since there is currently very little mobile usage for insurance-related activities in the region, more work is needed to train and educate insurance agents and consumers on how to use insurance mobile features. International organizations could also contribute by offering financial and technical assistance to increase ICT infrastructure in the region by increasing access, usage, and skills.

In terms of the limitations, the study considered 36 countries in SSA due to data availability issues for the other countries. Hence, future studies could increase the sample size by covering all African countries. Our results could also be extended by considering how ICT interacts with insurance in affecting inclusive growth. Further, this study was limited to country-level analysis; therefore, scholars could consider how ICT affects specific insurance companies' activities, such as claims and underwriting activities in the region.

Acknowledgement

The authors acknowledge the financial assistance from the National Research Foundation (NRF) of South Africa.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Statement of publication

This article has not been published elsewhere and has not been submitted simultaneously for publication elsewhere.

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Appendices

Appendix A

Table A1. Principal component analysis and eigenvalues of ICT diffusion.

Component	Eigenvalue	Difference	Proportion	Cumulative	KMO Statistic
Comp1	2.246	1.630	0.749	0.749	0.576
Comp2	0.616	0.478	0.205	0.954	0.587
Comp3	0.138	–	0.046	1.000	0.862
Overall					0.6211

Table A2. Eigenvectors of ICT diffusion index.

Variable	Comp1	Comp2	Comp3
Fixed Broadband	0.6246	−0.2879	−0.7259
Telephone	0.6105	−0.3997	0.6838
Internet	0.487	0.8703	0.0739

Appendix B: Estimations of the net effects (w.r.t insurance penetration)

Appendix B1: Main Analysis
Estimation of Net Effects in Table 4.

Model 9: $\frac{\partial GDPPCg}{\partial Total} = \beta_2 + \beta_4 \,\mathrm{ICT}_{it} = 0 = > 0.763 + 3.232(0.072) = 0.988$

Model 10: $\frac{\partial GDPPCg}{\partial Total} = \beta_2 + \beta_4 \,\mathrm{Fixed\ broadband}_{it} = 0 = > 0.457 + 0.366\ (0.824) = 0.758$

Model 11: $\frac{\partial GDPPCg}{\partial Total} = \beta_2 + \beta_4 \,\mathrm{Telephone}_{it} = 0\ = > 0.272 + 0.189\ (2.709) = 0.783$

Model 12: $\frac{\partial GDPPCg}{\partial Total} = \beta_2 + \beta_4 \,\mathrm{Mobile}_{it} = 0\ = > 0.303 + 0.008\ (14.833) = 0.422$

Estimation of Net Effects in Table 5.

Model 9: $\frac{\partial GDPPCg}{\partial Life} = \beta_2 + \beta_4 \text{ICT}_{it} = 0 \ => 0.411 + 2.123\ (0.072) = 0.563$

Model 10: $\frac{\partial GDPPCg}{\partial Life} = \beta_2 + \beta_4 \text{Fixed broadband}_{it} = 0 \ => 0.559 + 0.314\ (0.824) = 0.817$

Model 11: $\frac{\partial GDPPCg}{\partial Life} = \beta_2 + \beta_4 \text{Telephone}_{it} = 0 \ => 0.435 + 0.189\ (2.709) = 0.947$

Model 12: $\frac{\partial GDPPCg}{\partial Life} = \beta_2 + \beta_4 \text{Mobile}_{it} = 0 \ => 0.454 + 0.008\ (14.833) = 0.572$

Estimation of Net Effects in Table 6.

Model 9: $\frac{\partial GDPPCg}{\partial Nonlife} = \beta_2 + \beta_4 \text{ICT}_{it} = 0 \ => 3.467 + 3.103\ (0.072) = 3.690$

Model 10: $\frac{\partial GDPPCg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Fixedbroadband}_{it} = 0 \ => 2.361 + 0.596\ (0.824) = 2.852$

Model 11: $\frac{\partial GDPPCg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Telephone}_{it} = 0 \ => 5.445 + -1.613\ (2.709) = 1.075$

Model 12: $\frac{\partial GDPPCg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Mobile}_{it} = 0 \ => -1.644 + 0.032\ (14.833) = -1.169$

Appendix B2: Robustness Analysis

Estimation of Net Effects in Table 8.

Model 9: $\frac{\partial GDPg}{\partial Total} = \beta_2 + \beta_4 \text{ICT}_{it} = 0 \ => 1.349 + 2.815\ (0.072) = 1.552$

Model 10: $\frac{\partial GDPg}{\partial Total} = \beta_2 + \beta_4 \text{Fixed broadband}_{it} = 0 \ => 2.427 + 0.957\ (0.824) = 3.216$

Model 11: $\frac{\partial GDPg}{\partial Total} = \beta_2 + \beta_4 \text{Telephone}_{it} = 0 \ => 1.358 + 0.473\ (2.709) = 2.639$

Model 12: $\frac{\partial GDPg}{\partial Total} = \beta_2 + \beta_4 \text{Mobile}_{it} = 0 \ => 2.057 + 0.021\ (14.833) = 2.368$

Estimation of Net Effects in Table 9.

Model 9: $\frac{\partial GDPg}{\partial Life} = \beta_2 + \beta_4 \text{ICT}_{it} = 0 \ => 1.349 + 2.815\ (0.072) = 1.552$

Model 10: $\frac{\partial GDPg}{\partial Life} = \beta_2 + \beta_4 \text{Fixed broadband}_{it} = 0 \ => 2.942 + 0.664\ (0.824) = 3.489$

Model 11: $\frac{\partial GDPg}{\partial Life} = \beta_2 + \beta_4 \text{Telephone}_{it} = 0 \ => 1.923 + 0.450\ (2.709) = 3.142$

Model 12: $\frac{\partial GDPg}{\partial Life} = \beta_2 + \beta_4 \text{Mobile}_{it} = 0 \ => 2.616 + 0.021\ (14.833) = 2.927$

Estimation of Net Effects in Table 10.

Model 9: $\frac{\partial GDPg}{\partial Nonlife} = \beta_2 + \beta_4 \text{ICT}_{it} = 0 \ => 1.096 + 4.825\ (0.072) = 1.443$

Model 10: $\frac{\partial GDPg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Fixed broadband}_{it} = 0 \ => 6.311 + 1.187\ (0.824) = 7.289$

Model 11: $\frac{\partial GDPg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Telephone}_{it} = 0 \ => 1.401 + -2.494\ (2.709) = -5.746$

Model 12: $\frac{\partial GDPg}{\partial Nonlife} = \beta_2 + \beta_4 \text{Mobile}_{it} = 0 \ => 0.622 + 0.089\ (14.833) = 1.942$

Appendix C: Estimations of the net effects (w.r.t ICT variables)

Appendix C1: Main Analysis

Estimation of Net Effects in Table 4.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Total}_{it} => -0.611 + 3.131(1.608) = 4.423$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Total}_{it} => -1.629 + 0.366(1.608) = -1.041$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Total}_{it} => -0.920 + 0.189(1.608) = -0.616$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Total}_{it} => -0.036 + 0.018(1.608) = -0.036$

Estimation of Net Effects in Table 5.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Life}_{it} => -0.711 + 2.123(0.886) = 1.169$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Life}_{it} => -0.916 + 1.314\ (0.886) = 0.248$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Life}_{it} => -0.617 + 0.189(0.886) = -0.449$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Life}_{it} => -0.056 + 0.008(0.886) = -0.049$

Estimation of Net Effects in Table 6.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Nonlife}_{it} => -0.754 + 3.103(0.724) = 1.493$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Nonlife}_{it} => -1.231 + 0.596(0.724) = -0.799$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Nonlife}_{it} => 2.634 - 1.167(0.724) = 1.466$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Nonlife}_{it} => -0.074 + 0.023(0.724) = -0.050$

Appendix C2: Robustness Analysis

Estimation of Net Effects in Table 8.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Total}_{it} => -0.479 + 2.815(1.608) = 4.048$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Total}_{it} => -3.933 + 0.957(1.608) = -2.394$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Total}_{it} => -2.138 + 0.473(1.608) = -1.377$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Total}_{it} => -0.088 + 0.021(1.608) = -0.054$

Estimation of Net Effects in Table 9.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Life}_{it} => -0.915 + 2.949(0.886) = 1.697$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Life}_{it} => -0.620 + 0.664(0.886) = -0.032$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Life}_{it} => -1.326 + 0.450(0.886) = -0.927$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Life}_{it} => -0.060 + 0.021(0.886) = -0.041$

Estimation of Net Effects in Table 10.

Model 9: $\frac{\partial GDPPCg}{\partial ICT\ Index} = \beta_3 + \beta_4 \text{Nonlife}_{it} => 1.472 + 4.825(0.724) = 4.965$

Model 10: $\frac{\partial GDPPCg}{\partial Fixed\ Broadband} = \beta_3 + \beta_4 \text{Nonlife}_{it} => -2.163 + 1.187(0.724) = -1.304$

Model 11: $\frac{\partial GDPPCg}{\partial Telephone} = \beta_3 + \beta_4 \text{Nonlife}_{it} =>- 4.206 + 2.494(0.724) = 2.300$

Model 12: $\frac{\partial GDPPCg}{\partial Internet} = \beta_3 + \beta_4 \text{Nonlife}_{it} => -0.107 + 0.086(0.724) = -0.044$