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ARTICLE

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Impacts of ICT diffusion, foreign direct investment, trade openness, and globalization on growth in Sub-Saharan Africa

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Abstract

Over the past three decades, there has been a significant increase in information and communication technology (ICT) investments around the world, resulting in a rise in the use of modern ICT packages. Sub-Saharan African (SSA) countries, however, face different challenges. This study examines the relationship between ICT diffusion, foreign direct investment (FDI), trade openness, and economic globalization on inclusive growth for 48 SSA countries during 2005–2020. We use the modified generalized method of moments method for estimation. Empirical results reveal that ICT has a positive and significant influence on inclusive growth, while trade and economic globalization have a negative impact. FDI, on the other hand, has a favorable and considerable effect on inclusive growth. Inflation and vulnerable employment have negative impacts on inclusive growth, whereas social protection has a positive impact. From a policy standpoint, it is

recommended that policymakers focus on enhancing ICT penetration in the region, particularly integrating ICT into the educational system to improve learning effectiveness and reduce research costs. Additionally, the interaction between economic globalization and ICT diffusion can enhance inclusive growth. Therefore, macroeconomic policies should promote ICT development, implement sound trade agreements, and attract capital inflows for inclusive economic growth. ICT diffusion is deemed both necessary and sufficient for SSA's advancement.

KEYWORDS
FDI, globalization, ICT diffusion, inclusive growth, MGMM, Sub-Saharan Africa, trade

1 | INTRODUCTION

Information and communication technology (ICT) has over the years played a key role in transforming the global economy in different areas. These include the application of digital podiums by economic agents to access production resources, close information and knowledge gap, access market acumen and broad markets. Nair and Shariffadeen (2009) argued that using digital podium, consumers have been able to use shop automatons to acquire statistics about products and facilities around the world in a less cost manner. Over the last three decades, the world has witnessed high altitudes of investment in ICT which culminated in the rising applications of further up-to-date ICT packages such as cloud figuring facility, analytics of big data, and the internet itself, creativity resource development, and other digital mediums. In addition, firms can use the mutual intellect of all participants in the economy through the innovative ICT packages that are breeding new businesses and economic simulations. The enhancements of method developments, strength of new product advancement, promotion of robust world knowledge and advance webs have been made possible with the use of these novel ICT packages. These ICT tools have facilitated economic actors to separate space and time to improve market spread and fullness of products and services. The opening up of international markets, the rising returns on investment and value and the enhancement of innovative investment prospects for entire participants in the economy through these ICT tools have invariably led to improved international trade movements, foreign direct investment (FDI), and possibly economic progression (Arvin et al., 2021; Pradhan et al., 2019, 2022; Pradhan, Arvin, Hall, & Nair, 2017; Pradhan, Arvin, Hall, & Norman, 2017).

ICT has a tremendous influence on output, employment, and growth, and literature argues that it is the greatest essential element of economic expansion. With a 10% growth in digitalization and a constant unemployment rate, an economy's gross domestic product (GDP) grows by 0.75% (Sabbagh et al., 2013). The unemployment rate falls by 1.02% (Soomro et al., 2022). According to the OECD, ICT make it possible for people to access affordable health and education services while also creating new work opportunities. By creating new job opportunities and making it easier to obtain affordable health and education services, technological advancements can assist to eliminate poverty. The "gathering, storing, processing, sending hardware, software, networks, and multimedia, and displaying data (audio, data, text, and images)" are only a few of the various ICT components (World Bank, 2002). ICT has recently been seen as a key driver of economic growth for a number of explanations, comprising the ease with which a wide range of economic stakeholders can access knowledge and experience. Chen et al. (2018) reiterate that ICT has helped businesses become more productive by reducing the industrial outlays via the channel of communication. The

ability to connect to the internet lowers financial obstacles for firms and small and medium-sized enterprises, eliminating information asymmetries and agency expenses in the process. Bahrini and Qaffas (2019), have established a link between the growth of the economy and ICT. The ICT sector's explosive growth has raised the total output of the economy by enhancing the effectiveness and output of various industrial activities.

The importance of ICT infrastructure in a bid to draw foreign investment has transformed global system. Since 1980, developing country governments have assumed that FDI has a good influence on national progress and should be encouraged rather than discouraged (Asokan, 2014; Büthe & Milner, 2014; Philip et al., 2021). Attracting FDI is currently a key policy strategy for developing countries. Scholars view FDI as a catalyst and growth engine for diverse economies, according to the "New Theory of Economic Growth" (Cetin et al., 2015, 2018; Çetin & Ecevit, 2010; Cetin & Seker, 2012; Güngör et al., 2014; Hassan et al., 2015; Rahaman & Chakraborty, 2015; Seker et al., 2015). Additionally, FDI might impact per capita income and growth rates. The body of prior research demonstrates how FDI promotes the usage of local resources, allows access to new technologies, boosts the stock of human capital, and generates new employment prospects (Dương, 2017).

ICT has contributed significantly to the growth of globalization and has made it a reality. Due to rising competition and greater relevance of cost and economic scale, the market has been liberalized. As a result, these powerful forces helped to globalize the ICT industry (Drori, 2010; Rohman, 2013). Multinational enterprises are the vehicles for advancing globalization on a global scale; data demonstrates a high correlation between productivity improvements and the usage of ICT in these firms (Luo & Bu, 2016). However, the relationship between ICT and globalization is cyclical, with service provider companies under pressure to lead the market with cutting-edge technology as a result of competition among multiple globalization suppliers. On the other hand, as a result of these technologies, globalization advances even further, and so the cycle continues.

Many nations have implemented a variety of incentives and policies to improve trade openness in a concerted effort to draw the crucial FDI inflows for economic development. The demand for new technology has increased as a result of the increase in FDI inflows, which will help to ensure that investments are employed efficiently to produce higher returns on investments and value.

It is important to highlight that previous studies examining the relationship between ICT and economic growth have primarily focused on extensive expansion rather than a more equitable and socially impactful form of growth that goes beyond simply increasing the overall economic output. This emphasis is evident in discussions regarding the synergistic connection between ICT, FDI, trade openness, and economic growth. While the rate of economic growth in Africa has recently experienced an upturn, the issue lies in the simultaneous rise in inequality within the continent. Greenwald and Stiglitz (2013) and Kamah et al. (2021) have observed that economic expansion in African nations has occurred alongside increasing levels of inequality. Consequently, prioritizing conventional growth alone fails to advance the economy. According to Kraay (2004), effective and sustainable growth can only be achieved when it is inclusive in nature. For an extended period, conventional economic growth has been emphasized, as elucidated by Greenwald and Stiglitz (2013).

However, the recent trends in growth and inequality movements around the world have revealed certain problems in the trickle-down economics discussion. According to them, "the issue of income distribution was not given adequate attention, probably because of an implied notion in the trickledown effects—the notion that once an economy grows, then everyone enjoys from the growth." As a result of the awareness that the economic explanation of inclusive development and general economic growth are not the same, the study advances by speculating on the relationship between ICT diffusion, FDI inflows, trade openness, and inclusive growth. Inclusionary growth is "the practice and result where all the categories of people join in the shared expansion of the economy and have gained equally from the enhanced growth," according to Prasanna (2016). To put it another way, the concept of inclusive growth suggests that the benefits of expansion should be equally spread, with a particular emphasis on the poor because they are the ones who most need it. On this point, the current paper examines the sort of link between growth and ICT diffusion, FDI, and trade openness with a focus on inclusive growth relative to traditional economic growth that ignores the issues of the advantages of growth for society.

This present study also focuses on Sub-Saharan African's (SSA's) continent due to the devastating effects of the coronavirus disease 2019 (COVID-19) epidemic and the effective introduction of African Continental Free Trade Area (AfCFTA), being the leading free trade in the world. As a result, initiatives to promote inclusive growth in SSA countries have increased (Ofori et al., 2023; Ofori & Asongu, 2021). AfCFTA is expected to increase the incomes of an additional 68 million people who currently survive on less than $5.50 per day and bring 30 million people out of extreme poverty (World Bank, 2020). The AfCFTA, which has had a significant impact on the region, has allowed for the free flow of goods and services as well as a sizeable inflow of capital in the form of FDI into the African continent. Furthermore, the continent is endowed with a sizable active (youthful) population that has a voracious desire for ICT devices and associated services. ICT is growing and has a great potential for penetration across the African continent, although it is approaching saturation levels in advanced and emerging nations (Afutu-Kotey et al., 2017; Tchamyou et al., 2019). Additionally, ICT expansion and access in Africa have the prospect to raise the standard of living for those living in poverty and give them access to all of life's opportunities. Can the large potential benefits in wealth redistribution brought about by FDI influx, trade openness (globalization) and the quick adoption of ICT spur inclusive growth in SSA countries? As a result, this article uses a strong econometric approach to try and identify any complex endogenous and dynamic links that may exist between ICT connectivity, FDI inflows, trade-openness, globalization, and inclusive growth.

This work accordingly makes the following contributions. First, the study reconsiders the synergy nexus of ICT diffusion, FDI, trade openness, and globalization as a robust check and growth, that is, growth that acknowledges economic benefits superior to that of standard economic growth. A composite inclusive growth index, which incorporates a number of commonly used growth indicators, is used to measure this kind of growth. Second, as part of the study's use of a more comprehensive ICT measure, a composite ICT index that includes a variety of ICT indicators is computed. Third, the study interacts ICT with FDI, trade, and globalization (for robust check) which serve as diffusion mechanism on inclusive growth in SSA countries. Fourth, on a methodological strand, this study utilizes the modified generalized method of moments (MGMM) method which is a more robust analytical technique of estimation proposed by Kripfganz (2019) against the conventional generalized method of moments (GMM) estimation technique.

The following provides the remaining parts of the outline of the study: The review of literature, which follows the introduction, includes a theoretical and empirical structure that are discussed in Section 2. Data and method of analysis of the study are presented in Section 3, while Section 4 reports the results and discussions, which include the empirical data, methodology, and findings. Conclusion and policy recommendations where policy implications from the main findings are derived are provided in Section 5.

2 | LITERATURE REVIEW

The undeniable impacts of ICT, FDI, trade openness, and globalization cannot be ignored, particularly in terms of their influence on the economies, environments, and socio-cultural landscapes of interconnected nations. Notably, ICT plays a vital role in fostering economic expansion. ICT refers to the utilization of electronic and computer-based devices for accessing information and facilitating communication (ICT). This section aims to explore the theoretical relationship between ICT, FDI, trade openness, and growth, while also examining six empirical strands of literature that investigate specific causal relationships among the five variables: ICT, FDI, trade openness, globalization, and economic (inclusive) growth. These six strands of research are consolidated into a cohesive framework for the current investigation.

2.1 | ICT, FDI, trade, and growth (inclusive): A theoretical relationship

The neoclassical hypothesis is one of the most important hypotheses regarding the question of what drives economic expansion. The Solow growth model (Solow, 1956), one of the most well-known neo-classical models, serves

as the foundation for most studies on economic growth. Adding the technology level, which is viewed as an external component, as an independent variable in this model of economic growth, Solow sought to better explain how economic growth occurs. This model suggests that a number of elements, the most significant of which is a rise in technological level, can contribute to GDP growth. Regarding technological advancement and its effect on economic growth, reference is made to the model developed by Romer (1990), the father of the concept of internal growth. According to Romer, there should be a balance between production and research and innovation activities when allocating human capital. This is due to the fact that investing more human resources in research and innovation activities enables the economy to grow quickly and sustainably. According to Romer's model, the level of technological development always determines the level of output, which in turn depends on how human capital is distributed among various sorts of research and development activities.

Most economic development theories view investment in ICT as a crucial component of economic growth (Pohjola, 2002). However, empirical studies have produced contradictory findings, which differ depending on the research design and the study's sample or country. Models of economic growth take into account ICT investment as a key producer of labor, human capital, and physical capital. Through three major avenues, ICT can have an impact on three different aspects of economic growth: production, productivity, and economic growth.

First, ICT-related goods and services add value to the economy. Second, using ICT capital as an input in the production of all goods and services to increase output and productivity encourages economic growth. Not to mention, ICTs can boost economic growth through developing technology. Macroeconomic productivity growth will increase if the expansion of ICT output is based on the productivity and efficiency increases of activities (Nasab & Aghaei, 2009; Pohjola, 2002). Additionally, multiple microeconomic studies have shown a positive correlation between information technology investment and a number of economic success metrics for companies in industrialized countries (Brynjolfsson & Yang, 1966).

Two well-known contemporary theories, neo-Schumpeterian theories and neoclassical growth theories, have highlighted the existence of a significant and undeniable connection between ICT and economic growth (Pyka & Andersen, 2012; Schumpeter, 1934). These theories contend that ICT enters as a recommendation into the capital-related supply chain for business and improves the process that results by raising capital, expanding research, and raising the value of skilled labor. ICT consequently adds value at the firm and sectoral levels, improving output and accelerating business-related development at the national level (Aghaei & Rezagholizadeh, 2017; Bedia, 1999; Quah, 2002). Although hypothetical data implies that ICT has a meaningful effect on economic growth, actual study on this connection has yielded a variety of aggressive and contradictory outcomes.

The concept of rehabilitative theory, which suggests that FDI can contribute to the progress of recipient nations through the transfer of skills, utilization of innovation, and economic linkages, is supported by relevant studies (Bengoa & Sanchez-Robles, 2003; Durham, 2004; Li & Liu, 2005; Solomon, 2011). The relationship between the dissemination of ICT and inclusive growth is also theoretically supported by the sustainable livelihood approach (SLA) framework (Kwan & Chiu, 2015). This framework aligns with Sen's perspective on effective human behavior and functioning (Sen, 1999). The SLA framework encompasses the various connections between assets, enterprises, strategies, and individuals' livelihood outcomes (Messer & Townsley, 2003). Consequently, the framework illustrates how access to ICTs related to property and business activities promotes equality by empowering the public to enhance convenience and generate opportunities. Given its adaptability and relevance in addressing inclusive development issues, ICTs are integrated into the SLA framework (Duncombe, 2006).

2.2 | Research on the interaction among ICT, FDI, trade permeability, globalization, and growth (inclusive)

2.2.1 | ICT and growth (inclusive)

The first body of research examines the potential connection between ICT and economic expansion (see Figure 1).

Over the past 20 years, several research on the connection between ICT and economic growth have been conducted. The majority of studies backed the idea that ICT contributes to economic growth (Akadiri et al., 2020; Chakraborty, 2009; Erumban & Das, 2016; Ishida, 2015; Pradhan et al., 2014; Saint Akadiri et al., 2019; Shahiduzzaman & Alam, 2014; Vu, 2011). Emerging economies like Singapore, Hong Kong, South Korea, and Taiwan have become high-income industrial nations as a result of the effective and rapid spread of ICT, highlighting the technology's dynamic and quickly expanding potential. These various investigations have proven a strong causal connection between ICT and economic expansion. However, some research claim that the benefits of ICT on economic growth are vague and uncertain (Veeramacheneni et al., 2007). Some research indicate that ICT has a negative effect on employment and the labor market; these studies go on to explain that poverty and economic disparity have developed as a result because impoverished people have fewer resources to adopt contemporary information technology.

In the domestic ICT market, wealthy nations have an edge over emerging nations. Kraemer and Dedrick (1994) discovered a substantial relationship between IT investment and productivity growth in 12 countries in the Asia-Pacific region. Using a data set of 36 nations for the years 1985–1993, Dewan and Kraemer (1998) showed that investment in information technology is advantageous for industrialized countries but insignificant for developing countries. In the years 1980–1995 and 1985–1999, respectively, Pohjola (2000, 2002) carried out two 39- and 42-country studies. The results of the two-research confirmed Dewan and Kraemer's (2000) conclusion that while ICT does not significantly contribute to economic growth in developing nations, it does so in industrialized nations. However, studies that concentrated on a single country found that ICT did help to the economic growth in each of these nations (e.g., Jorgenson & Stiroh, 2000; Joseph, 2002; Kraemer & Dedrick, 2001; Oliner & Sichel, 2000; Tallon & Kraemer, 2000). Thanks in great part to this research, many economists today concur that ICTs increase FDI and economic growth. Additionally, Kurniawati (2021) discovered a causal relationship between ICT and economic growth in 25 high- and middle-income Asian nations using panel data spanning the years 2000–2018. The author of the study concluded that high-income Asian countries have had positive and notable economic growth as a result of the extensive use of the internet. Furthermore, middle-income countries are beginning to benefit from the advancement of the ICT index in terms of rapid economic growth.

In 2021, Sarangi and Pradhan conducted a theoretical analysis to investigate the impact of ICT infrastructure on economic growth (Sarangi & Pradhan, 2021). Their findings emphasized the importance of macroeconomic conditions, stable governance, sufficient funding, supportive policies, and an environment conducive to innovation as crucial factors for the prosperity enabled by ICT. Similarly, Hussein (2020) employed time series data methodology,

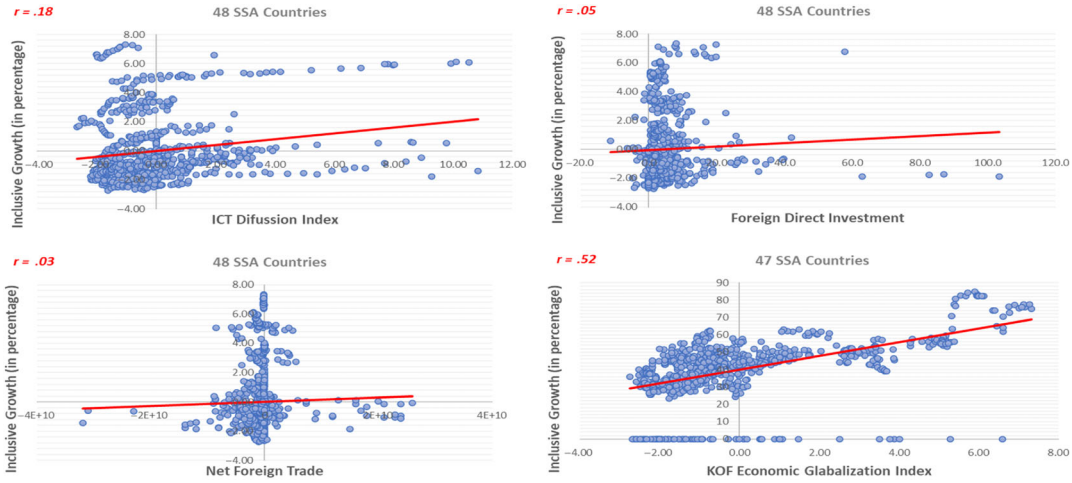

FIGURE 1 Linkages between inclusive growth, information and communication technology (ICT), foreign direct investment, trade, and globalization. SSA, Sub-Saharan African.

regression models with fixed effects, and regression models with random effects to explore the effects of ICT on inclusive growth. The study focused on a sample of developing nations and a sample of Arab nations, examining data from 2010 to 2018. The results revealed that both the access to and utilization of ICT have a positive and significant influence on overall economic growth, whether observed in the sample of developing countries or in the sample of Arab countries.

2.2.2 | Growth (inclusive) and FDI

In the second part of the essay, the discussion revolves around the growth of the economy and FDI. Several studies have examined the impact of foreign investment inflows on growth diffusion among Organization for Economic Co-operation and Development (OECD) member countries. Hejazi and Safarian (1999) found that foreign investment inflows significantly influence growth diffusion among OECD countries. Pilat and Lee (2001) conducted an analysis of OECD and non-OECD countries from 1970 to 1990 using time series regression and panel data regression. The empirical results indicated that the impact of capital inflows on GDP growth depends on the substitutability or complementarity of local and foreign capital in the selected region.

Hejazi and Safarian (1999) also examined panel data from 24 Chinese provinces between 1985 and 1996 and found that foreign capital inflows have a substantial impact on economic development. De Mello (1999) observed an immediate effect of FDI on economic growth in a sample of 24 developing countries. However, data from several East and Southeast Asian countries suggest that FDI inflows have a one-way impact on GDP through exports. Nair-Reichert and Weinhold (2001) noted that a group of emerging nations did not experience direct effects of FDI inflows on economic growth. Similarly, Alfaro (2003) argued that an increase in FDI inflows does not guarantee a corresponding increase in a country's GDP, with mixed effects observed in the manufacturing and primary sectors.

Nair-Reichert and Weinhold (2001) discovered a direct relationship between FDI growth and exports in their study of 66 developing countries. Hsiao and Hsiao (2006) analyzed data from various East and Southeast Asian countries and found that FDI inflows have a one-way impact on GDP through exports. Scholars researching the FDI-led growth hypothesis argue that FDI inflows contribute to economic growth by boosting aggregate demand, human capital development, and spillover efficiency (Akinlo, 2004; Borensztein et al., 1998; Organisation for Economic Co-operation and Development, 2002; Shakar & Aslam, 2015; Zhang & Yang, 2016; Zhao & Du, 2007; Zhu & Chen, 2016). For example, Fan and Hao (2020) suggest that China's economic growth rate could decrease by 3.4% based on their analysis.

2.2.3 | Trade openness and growth (inclusive)

The relationship between trade openness and economic growth can be understood through four different perspectives. The first perspective is based on Granger's theory, which suggests that increased trade openness can lead to higher economic growth. This theory rests on three pillars: firstly, more trade openness can stimulate economic growth through the international trade multiplier effect. Secondly, by boosting exports, countries can generate the necessary foreign currency to engage in global markets and acquire goods for economic production. Thirdly, nations can leverage economies of scale, reduce exposure to market volatility, and expand their market share through increased exports.

The second perspective is the trade openness-led economic growth theory, which argues that trade openness directly contributes to economic growth. Enhanced productivity, a sign of economic progress, can lead to higher returns on investment and return on value for investors. This, in turn, can elevate a country's status as an export base and strengthen its position in the global supply chain. Economic expansion generates income growth, enabling local

businesses and consumers to purchase more imported goods and subsequently increase imports into the domestic economy.

The third perspective is the feedback hypothesis, which posits that trade openness and economic growth are two independent variables that mutually support each other. This perspective acknowledges the simultaneous existence of the first two perspectives.

The fourth perspective is the neutrality hypothesis, which suggests that there is no causal relationship between trade openness and economic growth. Studies conducted by Huchet-Bourdon et al. (2017), Keho (2017), Pradhan and Arvin (2015), and Pradhan et al. (2016) have contributed to our understanding of the relationship between trade openness and economic growth.

2.2.4 | Economic expansion (inclusive) and globalization

The fourth area of the literature focuses on examining the relationship between economic growth and globalization. While some authors, such as Das (2010), argue that globalization is detrimental, the overall integration of financial and trade channels in the global economy has reached unprecedented levels over the past three decades. Various criteria have been utilized to investigate the connection between globalization and economic growth. For instance, Breznitz and Murphree (2011) analyze the capital account openness index, while Dreher (2006) highlights the negative impact of globalization on low-income countries. These studies often employ cross-sectional estimations, which consider constant characteristics over time.

Other studies utilize modern panel data techniques to explore the relationship between globalization and economic growth. Dreher et al. (2008) conducted a recent study investigating the link between accelerated economic growth, increasing trade openness, and foreign investment. Sbia et al. (2014), in their investigation of the relationship between various aspects of economic growth and globalization, find a positive link in terms of FDI. A comprehensive analysis of the relationship between globalization and economic expansion was conducted by Adhikary (2010), specifically focusing on Bangladesh. The study reveals a significant impact of globalization on economic growth and argues for its beneficial effects. It is important to note that these studies collectively contribute to our understanding of the relationship between economic growth and globalization. However, there may be variations in findings depending on specific contexts and methodologies employed.

3 | DATA AND METHODOLOGY

3.1 | Data and sources

The study utilizes panel datasets of 48 SSA countries over the period 2005–2020. The year 2005 is chosen as the starting year of the study to allow for more inclusion of SSA countries, justified by the lack of ICT data prior to this point in most of the countries in the SSA region (Bello et al., 2022). Specifically, data limitations constrained our ability to extend the analysis further back in time. Many SSA countries have inadequate data availability on key indicators before 2005. Additionally, some of the ICD indicators utilized in our study are not yet available beyond 2020. We chose the 2005–2020 period as it represents the most comprehensive balanced panel dataset currently available for the countries and variables included in our analysis given these data constraints.

The key variables of the study include the inclusive growth index, diffusion index, FDI, trade, and KOF economic globalization index. The inclusive growth and ICT index are constructed using principal component analysis (PCA; see Tables 1 and 2), while the economic globalization index is proxied by KOF economic globalization index. One of the novelties of this research work is the construction of the inclusive growth index, which provides a new composite measure of inclusive growth tailored to the context of SSA. While previous studies have attempted to quantify

inclusive growth, our index incorporates a wider range of indicators spanning access, equity, social protection, and governance dimensions based on data availability for the region (Anand et al., 2013). As shown in Appendix B, we include sanitation access, electricity access, Gini index, education and health expenditures, employment, clean fuel access, social protection, rule of law, and voice and accountability as key indicators that capture inclusive growth from various angles. The high correlations between many of these indicators provide justification for combining them into a single index as we have done. Our inclusive growth index builds on recent work utilizing multidimensional approaches to measuring inclusive growth and shared prosperity (Ranieri & Ramos, 2013; Rauniyar & Kanbur, 2010). By tailoring the index specifically to data availability and development challenges in SSA, this study contributes a context-specific measurement tool for policymakers and researchers examining inclusive growth in the region. We believe the index provides a novel way to quantify inclusive growth while encompassing its multidimensional nature.

Other variables include FDI, and trade are measured as net FDI inflow and net foreign trade as % of GDP, respectively. FDI and trade openness are included as key independent variables influencing inclusive growth based

TABLE 1 Variables and unit of measurements.

Variables	Unit of measurement	Sources
igr_ind	Inclusive growth index constructed using PCA	Author
ict_ind	ICT index constructed using PCA	Author
fdi	Foreign direct investment, net inflows (% of GDP)	WDI
net_trad	Trade (% of GDP)	WDI
egi	Economic globalization index	KOF
infl	Consumer price index (2010 = 100)	WDI
vul_empl	Total contributing family and own-account workers (as a share of employment)	WDI
soc_empl	Coverage of social protection and labor programs (% of the population)	WDI
pers_rem	Remittance inflows to GDP (%)	WDI

Abbreviations: GDP, gross domestic product; ICT, information and communication technology; PCA, principal component analysis; WDI, World Development Indicators.

TABLE 2 Principal components and eigenvalues (information and communication technology diffusion).

Component	Eigenvalue	Difference	Proportion	Cumulative	KMO statistic
PC1	4.0264	1.8227	0.3355	0.3355	0.7652
PC2	2.2037	1.0421	0.1836	0.5192	0.5483
PC3	1.1615	0.2680	0.0968	0.6160	0.7832
PC4	0.8934	0.0434	0.0745	0.6904	0.7856
PC5	0.8500	0.0895	0.0708	0.7613	0.8247
PC6	0.7605	0.0657	0.0634	0.8247	0.6873
PC7	0.6947	0.2510	0.0579	0.8825	0.7130
PC8	0.4436	0.0752	0.0370	0.9195	0.6576
PC9	0.3684	0.0990	0.0307	0.9502	0.6937
PC10	0.2694	0.0932	0.0225	0.9727	0.7022
PC11	0.1762	0.0245	0.0147	0.9874	0.8867
PC12	0.1516		0.0126	1.0000	0.7622
Overall	–	–	–	–	0.7415

Abbreviations: KMO, Kaiser–Meyer–Olkin; PC, principal component.

on past empirical studies and theoretical models linking FDI and trade to economic growth and development (Borensztein et al., 1998; Dollar & Kraay, 2004). FDI can facilitate technology transfer and knowledge spillovers, while trade openness supports competitive pressures and efficient resource allocation (Organisation for Economic Co-operation and Development, 2002). Thus, we include net FDI inflow and net foreign trade as percentages of GDP to account for the potential growth impacts of capital flows and trade. Our measurement selections align with previous macroeconomic analyses utilizing these indicators as proxies for FDI and trade (Mold, 2003; Sakyi et al., 2012). By incorporating FDI and trade openness, we account for two key aspects of global economic integration suggested by the literature as drivers of growth and inclusion outcomes.

We utilize a number of indicators to create a composite index for inclusive growth using PCA, as recommended by the Asian Development Bank (2013). Similarly, we construct an index for ICT diffusion using 11 indicators based on the procedure described by the international telecommunication union.[1]

Table 1 summarizes the descriptions and sources of all the variables of interest. In addition to the five main variables explained above, we use inflation as captured by consumer price index (2010 = 100), vulnerable unemployment as captured by the total contributing family and own-account workers (as share of employment), social protection measured as coverage of social protection and labour programs (% of the population) and trade as captured by trade (% of GDP) as the control variables. The selection of these variables is inspired by related studies that found inflation and vulnerable employment are detrimental to shared prosperity whereas trade and social inclusion are its promoter (Asongu & Nwachukwu, 2017; Ofori & Asongu, 2021). All the datasets were sourced from the World Bank development indicators except for the KOF economic globalization index which was retrieved from KOF Time Series Database.

3.2 | Model and estimation technique

Following the underpinning theories and related empirical literature on the subject matter, we built our models based on the schematic diagram depicted in Figure 2 to explain the dynamic relationships among the five main variables of interest.

Inclusive growth (igr_ind) is the dependent variable and it is influenced by the four independent variables which include, fdi, trade (net_trad), ict diffusion (ict_ind) and economic globalization index (egi) directly (indicated by the light black arrows in Figure 2). Moreover, igr can be influenced indirectly by ict through fdi, trd and egi. For this reason, we created three interaction terms, namely ict_ind × fdi, ict_ind × net_trad and ict_ind × egi to show the indirect impact indicated by the tick blue arrows in Figure 1.

The static econometric model specification is as follows:

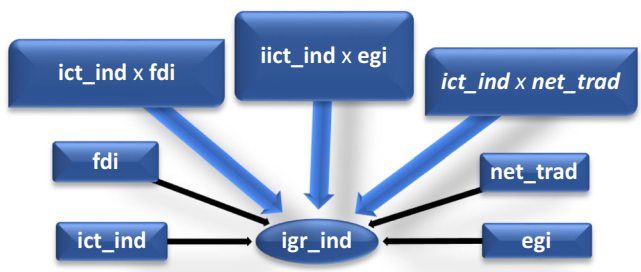

FIGURE 2 Dynamics of information and communication technology, foreign direct investment, trade, globalization, and inclusive growth.

$$\text{igr\_ind}_{it} = \beta_0 + \beta_1 \text{ict\_ind}_{it} + \beta_2 \text{fdi}_{it} + \beta_3 \text{net\_trad}_{it} + \beta_4 \text{egi}_{it} + \beta_5 X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where $i = 1, 2,\ldots, n$ number of countries, while t, $t-1$ are the current and previous year time periods, respectively; igr_ind, ict_ind, fdi, net_trad, and egi are inclusive growth, ICT diffusion, FDI, net foreign trade, and KOF economic globalization index, respectively. The X is a vector of control variables which includes inflation, vulnerable employment, and social protection; and ε_{it} is the unobserved country-specific fixed effects.

The dynamic model can be specified as:

$$\begin{aligned}\text{igr\_ind}_{it} = {} & \beta_1 \text{igr\_ind}_{i,t-1} + \beta_2 \text{ict\_ind}_{i,t-1} + \beta_3 \text{fdi}_{i,t-1} \\ & + \beta_4 \text{net\_trad}_{i,t-1} + \beta_5 \text{egi}_{i,t-1} + \beta_6 X_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it}.\end{aligned} \quad (2)$$

Equation (2) has two extra error terms in addition to the country-specific fixed effects error terms: μ_i and λ_t which are the idiosyncratic error terms and the unobserved time effects, respectively.

Based on econometric prudence, Equation (2) is re-specified to include three different interaction terms as follows:

$$\begin{aligned}\text{igr\_ind}_{it} = {} & \beta_1 \text{igr\_ind}_{i,t-1} + \beta_2 \text{ict\_ind}_{i,t-1} + \beta_3 \text{fdi}_{i,t-1} + \beta_4 \text{ner\_trad}_{i,t-1} \\ & + \beta_5 \text{egi}_{i,t-1} + \beta_6 (\text{ict\_ind} \times \text{fdi})_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it}\end{aligned} \quad (3)$$

$$\begin{aligned}\text{igr\_ind}_{it} = {} & \beta_1 \text{igr\_ind}_{i,t-1} + \beta_2 \text{ict\_ind}_{i,t-1} + \beta_3 \text{fdi}_{i,t-1} + \beta_4 \text{net\_trad}_{i,t-1} \\ & + \beta_5 \text{egi}_{i,t-1} + \beta_6 (\text{ict\_ind} \times \text{net\_trad}) + \mu_i + \lambda_t + \varepsilon_{it}\end{aligned} \quad (4)$$

$$\begin{aligned}\text{igr\_ind}_{it} = {} & \beta_1 \text{igr\_ind}_{i,t-1} + \beta_2 \text{ict\_ind}_{i,t-1} + \beta_3 \text{fdi}_{i,t-1} + \beta_4 \text{trad}_{i,t-1} \\ & + \beta_5 \text{egi}_{i,t-1} + \beta_6 (\text{ict\_ind} \times \text{egi})_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it}\end{aligned} \quad (5)$$

where, ict_ind × fdi is the interaction term for ICT and FDI, ict_ind × net_trad is the interaction term for ICT and trade and ict_ind × egi is the interaction term for ICT and economic globalization index. Based on our a priori expectations (see Figure 1), we expect all the parameters in the above models to be positive. For the incorporated interaction terms, the net effect can be expresses as follow:

$$\begin{aligned}\frac{\partial(\text{igr\_ind})}{\partial(\text{fdi})} &= \beta_3 + \beta_6 \sqrt{\text{ict\_ind}} \\ \frac{\partial(\text{igr\_ind})}{\partial(\text{net\_trad})} &= \beta_4 + \beta_6 \sqrt{\text{ict\_ind}} \\ \frac{\partial(\text{igr\_ind})}{\partial(\text{egi})} &= \beta_5 + \beta_6 \sqrt{\text{ict\_ind}}\end{aligned}$$

where $\sqrt{\text{ict\_ind}}$ is the mean score of the ICT index. At this juncture, it is imperative to point out that in estimating Equation (3) through Equation (5), endogeneity problem may arise because of the inclusion of the lag of dependent variable (igr_ind) as the independent variable. However, we address this concern by applying the system of GMM technique[2] as proposed by Arellano and Bover (1995).

To validate our GMM estimated results, we subjected the estimated models to three robustness tests, namely, Breusch-Pagan, Hausman, and Wooldridge tests. In addition, we performed several post estimation tests to find out if there are second-order serial correlation and whether the instruments are valid. Overall, this pre and post estimation tests will ensure the reliability of our GMM estimations.

4 | RESULTS AND DISCUSSION

4.1 | Pre-estimation diagnostics

4.1.1 | ICT diffusion index

As previously stated, the study departs from many past studies by developing a composite indicator for ICT diffusion based on the International Communication Union classification. The index is calculated using PCA and a total of 12 indicators (PCA). Table 1 displays these indicators.

PCA involves several preliminary tests, all of which the study passes. Meanwhile, we look for: (i) a large sample of ICT covariates. (ii), the level of correlation between these factors. (iii), the magnitude of the partial and overall inter-correlations of these indicators. Appendix A depicts highly correlated confounders to assist in selecting these indicators. Furthermore, based on the Bartlett Chi (χ^2) statistic of 1061.52 and the corresponding *p*-value (.0000),

TABLE 3 Principal components and eigenvalues (inclusive growth index).

Component	Eigenvalue	Difference	Proportion	Cumulative	KMO statistic
PC1	5.0402	2.8898	0.4200	0.4200	0.9025
PC2	2.1504	0.9691	0.1792	0.5992	0.8852
PC3	1.1813	0.1440	0.0984	0.6977	0.6086
PC4	1.0372	0.4476	0.0864	0.7841	0.8635
PC5	0.5895	0.1093	0.0491	0.8332	0.4983
PC6	0.7605	0.0825	0.0400	0.8733	0.8393
PC7	0.6947	0.0235	0.0331	0.9064	0.8638
PC8	0.4436	0.1148	0.0312	0.9376	0.8801
PC9	0.3684	0.0595	0.0216	0.9592	0.7135
PC10	0.2694	0.0197	0.0166	0.9758	0.7184
PC11	0.1762	0.0697	0.0150	0.9908	0.6814
PC12	0.1516	–	0.0092	1.0000	0.8447
Overall	–	–	–	–	0.8078

Abbreviations: KMO, Kaiser–Meyer–Olkin; PC, PCA, principal component.

TABLE 4 Summary statistics (full sample).

Variable	Observation	Mean	Std. dev.	Minimum	Maximum
lgr_ind	767	−1.04e−09	2.2450	−2.7475	7.3284
ict_ind	752	−1.18e−08	2.0066	−2.6628	10.8445
fdi	739	4.8883	8.5199	−11.199	103.337
Net_trad	638	−7.98e+08	4.63e+09	−3.20e+10	2.60e+10
EGI	693	44.3196	11.0366	23.3961	84.9065
infl	704	9.400231	29.34177	−8.97474	557.202
Vul_empl	705	69.61325	21.72441	8.83	94.4
Soc_prot	421	26.40467	29.06826	−114.297	105.5269
Pers_rem	647	3.938743	5.493722	0.1832	37.93965

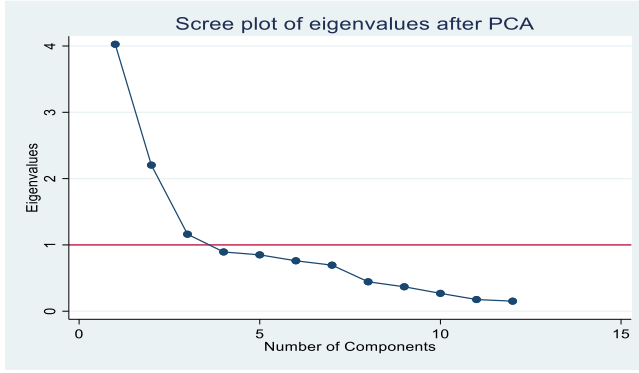

FIGURE 3 Screen plot of principal components of information and communication technology diffusion. PCA, principal component analysis.

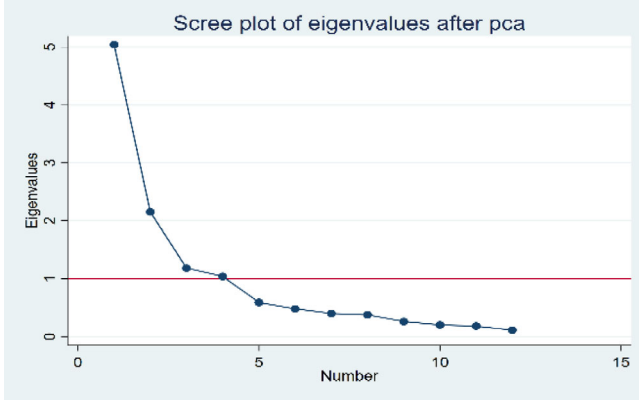

FIGURE 4 Screen plot of principal components of inclusive growth. PCA, principal component analysis.

the test indicates substantial inter-correlations between these indicators. Two displays the Kaiser–Meyer–Olkin (KMO) statistics, which illustrate the overall and partial inter-correlations between the indicators. The presence of KMO statistics greater than 0.5 suggests that the sample used to produce the ICT diffusion index is sufficient.

We proceed to develop a composite ICT index after passing the basic tests by normalizing these indicators to reach a zero (0) mean and a standard deviation of one (1) based on the various scales these indicators assume (Jolliffe, 2002). In the same way, Table 4 displays the difference, proportion, cumulative, and eigenvalues of these components. To produce a composite ICT index, we keep three components whose eigenvalues are bigger than one (1) in accordance with the Kaiser rule of eigenvalues, as suggested by Ofori and Asongu (2021) and Tchamyou et al. (2019). These three retained components give our data significant (61.6%) information. Table 4 and Figure 3 both confirm previous statement.

4.1.2 | Inclusive growth index

We go into great depth on the creation of an ICT diffusion composite index in the section before this one. This section also describes how to develop an inclusive growth index. As recommended by the Asian Development Bank (2013), we employ PCA to produce an inclusive growth index based on the identification of numerous characteristics

TABLE 5 Estimation results for models (static) without interaction.

Variables	Pooled-OLS	Fixed effects	Random effects
ict_ind	0.294** (0.007)	0.143** (0.037)	0.379** (0.038)
fdi	0.0174*** (0.000)	−1.121 (0.996)	−0.063 (0.633)
net_trad	−0.562** (0.022)	−0.861** (0.014)	−1.391** (0.024)
egi	0.0515*** (0.000)	−0.012*** (0.000)	−0.061** (0.010)
infl	−0.029*** (0.000)	−0.055** (0.012)	0.018 (0.495)
vul_empl	−0.067*** (0.000)	−0.044** (0.028)	−0.042*** (0.000)
soc_prot	0.073** (0.004)	0.017*** (0.001)	0.017** (0.006)
pers_rem	0.032 (0.602)	−0.031 (0.523)	−0.015** (0.008)
Constant	2.592*** (0.000)	4.296*** (0.000)	−7.626*** (0.000)
Observations	307	307	307
R^2	.921	.765	–
Year dummies, yes	–	Yes	Yes
Post-estimation diagnostics			
Breusch–Pagan LM test	–	–	0.0000
Hausman (*p*-value)	–	.0000	–
Wooldridge (*p*-value)		.0167	

Note: The parenthesis contains the probability values.
Abbreviations: LM, Lagrange multiplier; OLS, ordinary least squares.
***$p < .01$, **$p < .05$, *$p < .1$.

that constitute inclusive growth in developing nations. The indicators used to generate this index are shown in Table 5.

Like the ICT index, the inclusive growth index passes all preliminary tests. Appendix B demonstrates a higher correlation between the covariates. We confirm that the overall covariates are interconnected based on the 564.85 Chi (χ^2) statistic and .000 matching *p*-value. The 0.8078 KMO statistic shown in Table 5 verifies the index's sampling adequacy. Because the scales of these indicators differ, we equalize them to produce a zero mean and a standard deviation of one (1). We keep four components with eigenvalues greater than one to produce a composite inclusive growth index (1). When the retained components are added together, they explain 78.5% of the information in the data. A scree plot of the elements of inclusive growth is shown in Figure 4 and is consistent with Table 3.

4.1.3 | Summary statistics

Table 4 shows the descriptive statistics for the variables in the study. While inflation is the variable with the greatest degree of dispersion, vulnerable employment has the highest mean value and records the highest single number. Trade, on the other hand, records the lowest value. Additionally, the Pearson correlation coefficient plots a line of best fit through the data of the two factors and measures the strength and bearing of affiliation between two variables. Appendix C contains the correlation matrix. A significant linear relationship between the independent variables and the dependent variable so occurs in both positive and negative directions.

A non-parametric method for understanding the relationship between two or more variables is the bin scatter plot. It computes the average of the dependent variable within each bin after dividing it into equal-sized bins. Bin scatter plots to aid in reflecting population behavior rather than just that of the study's sample.

TABLE 6 Estimation results for models (static) with interaction.

Variables	Pooled-OLS	Fixed effects	Random effects
ict_ind	0.216*** (0.000)	0.346** (0.032)	0.272** (0.051)
fdi	0.014*** (0.000)	0.694 (0.095)	−0.069 (0.623)
net_trad	−1.311** (0.007)	−0.812** (0.035)	−1.132** (0.007)
egi	0.036*** (0.000)	−0.012*** (0.000)	−0.078** (0.051)
ict_ind × fdi	0.002 (0.314)	0.065 (0.894)	−0.023 (0.768)
ict_ind × net_trad	−1.111*** (0.000)	−0.213** (0.046)	−0.632** (0.040)
ict_ind × egi	0.004*** (0.000)	0.007 (0.123)	−0.011** (0.047)
infl	−0.028*** (0.000)	−0.069** (0.030)	0.021** (0.427)
vul_empl	−0.069*** (0.000)	−0.044** (0.028)	−0.042*** (0.000)
soc_prot	0.055*** (0.001)	0.018*** (0.001)	0.018** (0.005)
pers_rem	0.035 (0.562)	−0.025 (0.600)	−0.013** (0.015)
Constant	3.335*** (0.000)	−2.296*** (0.000)	−6.099*** (0.000)
Observations	307	307	307
R^2	.926	.767	–
Year dummies	–	–	–
Post-estimation diagnostics			
Breusch–Pagan LM test	–	–	0.0000
Hausman (*p*-value)	–	.0000	–
Wooldridge (*p*-value)	–	.0272	–

Note: The parenthesis contains the probability values.
Abbreviations: LM, Lagrange multiplier; OLS, ordinary least squares.
***$p < .01$, **$p < .05$, *$p < .1$.

4.2 | Main findings

Table 5 displays the findings of the static models; pooled-ordinary least squares (OLS), fixed effects, and random effects estimators, which are represented by Equation (1). We run Breusch–Pagan and Hausman tests to determine which estimators are the most consistent and efficient. The Breusch–Pagan Lagrange multiplier test results show a significant *p*-value (.000), indicating that the random individual effects are legitimate and have non-zero variances (Baltagi, 2005). As a result, we receive biased results from pooled OLS estimation of Equation (1). We compare fixed effects and random effects estimators using a robust Hausman test to identify an efficient and consistent estimator. This test yields a significant *p*-value (.000), rejecting the null hypothesis of random effects. As a result, as a consistent and efficient estimator, a fixed-effects estimator is proposed.

The second columns of Tables 5 and 6 both contain the findings of the fixed effects estimation. Table 5 shows that whereas ICT has a positive significant influence on inclusive growth, trade and economic globalization have a negative significant effect. According to the model's control variables, inflation, and vulnerable employment have a negative impact on inclusive growth, whereas social protection has a favorable impact on this shared growth. Table 6 shows the interaction effect results, which suggest that the interaction effect of ICT diffusion and trade mitigates the detrimental effect of trade openness on inclusive growth. The control variable results are identical to those in Table 5. According to the findings, trade openness does not promote shared prosperity, whereas ICT diffusion promotes inclusive economic growth in SSA.

On the other hand, a consistent fixed effects estimator requires stringent exogeneity of the regressors. To check the exogeneity of these regressors in the equation, we use the Wooldridge test (1). The test results show a significant *p*-value (.000), rejecting the null hypothesis of no first-order serial correlation. This disproves the fixed effects model's assumption that the regressors are wholly exogenous and supports a relationship between potential regressor values and the error term. Therefore, the fixed effects model's parameter estimations are skewed and inconsistent.

According to the literature, GMM controls for unobserved heterogeneity and prevents biased estimates when the dependent variable has a time lag (Nickell, 1981). We adhere to the recommendations of Kiviet (2020) and Kripfganz (2019) and perform model specification exploration as a precondition for developing an efficient and consistent GMM estimator. The process of defining the model aims to categorize all-important regressors as strictly exogenous, endogenous, or present in accordance with economic theory. The absence of correlation between regressors and error terms (time-variant) classifies a variable as strictly exogenous, whereas the inverse is true for endogenous variables. Predetermined variables are those that could be associated with previous values of time-variant error terms but not with the present or future values of those terms.

As per the identification process, the exclusion restriction hypothesis posits that solely exogenous factors exert influence on the outcome variables, specifically inclusive growth, through predetermined channels or exogenous elements of the independent variables. The underlying premise of this assumption forms the basis of the identification process, which is in consistency with the current body of literature focused on the GMM (Boateng et al., 2018). According to Roodman (2009), who holds a favorable stance towards this approach, it is contended that time-invariant variables possess the potential to be employed as strictly exogenous variables. This is due to the low probability of these variables becoming endogenous when considering the first difference series. The examination of instrument exogeneity in the Hansen test is undertaken with consideration of the elucidated identification process. In this test, the alternative hypothesis suggests that the exogenous variables used may not be valid instruments. This means that they could potentially impact the outcome variable in a manner that is distinct from the proposed exogenous explanatory variables or mechanisms. Based on this null hypothesis, it is suggested that the exogenous variables will only have an impact on inclusive growth through the involved independent variables and control variables. In the context of GMM, this clarification does not deviate from the more conventional approaches of GMM. These approaches involve rejecting the alternative hypothesis of the Sargan–Hansen test, which confirms that the adopted instruments strictly exogenously influence real per capita GDP solely through the proposed mechanisms (Amavilah et al., 2017). The utilization of lags of endogenous regressors is employed as a means to identify the endogenous regressors within the current study. The endogeneity issue has been addressed in other studies through the use of internally generated instruments (Donou-Adonsou, 2019).

Following an intense model search, we use a one-step difference GMM estimator. The model passes all of the post-estimation tests and fits our data very well. The findings of the basic GMM model are presented in column (1) of Table 7. According to the findings, an increase in ICT leads to a 0.036% increase in inclusive growth. This is a small but substantial contribution of ICT to shared prosperity in SSA. This finding supports and is consistent with previous research findings. Most existing studies argue that ICT diffusion improves common people's access to huge economic prospects by making information more accessible, hence improving economic inclusion (Adeleye et al., 2021; Ofori & Asongu, 2021). ICT diffusion improves information access, lowers information barriers, and exposes people to new opportunities. It boosts teaching and learning effectiveness while lowering research costs. It increases the effectiveness and efficiency of healthcare services. All of this leads to increased economic inclusion for people. The findings also suggest that FDI has a favorable and considerable impact on inclusive growth. A percent increase in FDI boosts inclusive growth by 0.014%. Kang and Martinez-Vazquez (2021), Munir and Fatima (2020), and Ofori and Asongu (2021) all argue that FDI is an important instrument for promoting inclusive growth, particularly in low- and middle-income countries. FDI has the potential to contribute to inclusive development in SSA by facilitating the transfer of technology, improving access to international markets, increasing employment opportunities, raising wages, and reducing the cost of living.

TABLE 7 Generalized method of moments. estimation results (one-step difference).

Variables	1	2	3	4
igr_ind	0.713*** (0.0292)	0.669*** (0.0414)	0.662*** (0.0433)	0.669*** (0.0428)
ict_ind	0.036** (0.0128)	0.042** (0.0144)	0.049*** (0.0159)	0.043*** (0.0037)
Fdi	0.018** (0.0044)	0.099** (0.0476)	0.011** (0.0437)	0.012*** (0.0043)
net_trad	−1.062** (0.9613)	−1.7112** (0.8413)	−1.9713*** (0.4012)	−1.7612** (0.6313)
egi	−0.053* (0.0265)	−0.053* (0.0294)	−0.014** (0.0027)	−0.048* (0.0225)
ict_ind × fdi		0.195** (0.0266)		
ict_ind × net_trad			−0.512** (0.2112)	
ict_ind × egi				−0.0184** (0.0045)
infl	−0.026 (0.0197)	−0.0218 (0.0222)	−0.025 (0.0213)	−0.022 (0.0194)
vul_empl	−0.012*** (0.0036)	−0.015*** (0.0046)	−0.017*** (0.0053)	−0.015*** (0.0047)
soc_prot	0.048*** (0.0041)	0.0545*** (0.0044)	0.018** (0.0045)	0.0468** (0.0045)
pers_rem	−0.004 (0.0034)	−0.004 (0.0034)	−0.047 (0.0349)	−0.004 (0.0033)
constant	−2.535*** (0.7638)	−4.621*** (1.637)	−3.953*** (0.8754)	−3.2612*** (1.0267)
Observations	307	307	307	307
R^2	–	–	–	–
Year dummies	–	–	–	
Post-estimation diagnostics				
Hansen–Sargan (*p*-value)	.462	.314	.326	.245
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.372	0.527	0.625	0.675

Note: The parenthesis contains the robust standard errors.
***p < .01; **p < .05; *p < .1.

Trade openness, contrary to our assumptions, does not foster inclusive growth in the region. According to our baseline model, a percent increase in trade openness results in a −1.062% drop in inclusive growth. As a result, trade openness in the region reduces shared prosperity, confirming our second hypothesis. Evidence also demonstrates that when trade openness increases, inequality rises in many developing and rising nations (Bauer & Boussard, 2021; Ravallion, 2018). Many countries, particularly sophisticated ones, blame increased trade openness on the loss of manufacturing employment and bad economic conditions (IMF, 2020). SSA does poorly in terms of sharing the benefits of trade openness. The majority of the countries in the region have a balance of payments deficits. The region has the world's lowest intra-regional trade and the highest trade with countries outside its domain. In terms of modern technology, infrastructure development, and capital base, countries like China who are the biggest region's trading partners have a competitive advantage. Jobs are lost in the value chain of this trade, undermining shared prosperity in the region.

We also find empirical evidence for our second goal. Columns 2 and 3 of Table 7 show the outcome of our interaction terms. Column (2) results demonstrate a positive interaction effect of ICT and FDI, meaning that the beneficial effect of FDI on inclusive growth is stronger when ICT development is present. The interaction impact of FDI can result in a 0.195% increase in shared prosperity. Our findings support the idea that boosting ICT diffusion might boost shared prosperity. ICT development enhances access to information, creates job opportunities, and raises positive externalities in terms of knowledge spill-over effects. ICT spread could assist the masses in capitalizing on the opportunities presented by the increased infusion of FDI into the SSA. ICTs have the potential to attract FDI in

various sectors such as finance, manufacturing, and telecommunications. This is because ICTs can effectively reduce risks for managers, lower production, and transaction costs, and provide access to a wide market. Additionally, ICTs facilitate the transfer of innovation, which contributes to inclusive economic growth.

The findings concerning the synergistic effect of ICT and trade openness on inclusive growth are revealed in Column 3. ICT diffusion favorably promotes inclusive growth, and the synergy effect can create shared prosperity in the region, whereas trade openness hinders inclusive growth. Inferentially, ICT use reduces the detrimental effects of trade openness on inclusive growth. ICT use, such as e-commerce and digital trade, is increasing global trade levels. Digital technologies minimize trade expenses, face-to-face interaction, and legislative barriers while also improving trade services. As digital technologies advance trade services, a 50% increase in the service sector's share in global trade is (World Trade Organization, 2019). The advent of digitalization has introduced efficient methods to mitigate the challenges posed by size disparities in international trade. One such method is the reduction of overall costs related to transportation and border operations. More so, SSA could leverage digital technology to gain from trade openness thanks to the region's growing ICT adoption, especially in this ACFTA era. There is a lot of hope that when ACFTA goes into effect, ICT diffusion would facilitate intra-regional trade, boosting inclusive growth in Africa.

The results of the control variables show that there is little difference between the two models — main and interaction. According to the main model, a percent increase in social protection raises shared prosperity by 0.048%, while a percent rise in vulnerable employment lessens shared prosperity by −0.012%. The interaction models show the same signs for both variables. Evidently, social protection programs promote shared prosperity, whereas vulnerable employment hinders it. Meanwhile, we discover that well-resourced institutions for deterring, controlling, and tackling scenarios that harm the welfare of the poor and needy can have tremendous inclusive growth-inducing effects. The negative impact of vulnerable employment on inclusive growth highlights the importance of good macroeconomic planning and the creation of better economic employment options, both of which are required for long-term wealth accumulation and the development of the masses' capacity to gear up for, endure, or adapt to socio-economic shocks. The results of the post-estimation tests show all the GMM (one-step difference) models pass both serial correlations of order one (AR(1)) and order two (AR(2)) tests. The models also successfully pass the Hansen–Sargan tests with *p*-values well above .1. Therefore, we conclude that our estimates are reliable and that the model fits our data well.

4.3 | Robustness check

We examine the robustness of our findings by incorporating economic globalization and its interaction term into all our models. The main GMM model results demonstrate a negative link between economic globalization and inclusive growth, meaning that a 1% increase in economic globalization results in a −0.053% reduction in inclusive growth. The findings demonstrate that the negative consequences of cross-border trade and financial flows outweigh potential development and social infrastructure gains (see Alvaredo et al., 2017; Opoku & Boachie, 2020).

We now investigate whether ICT diffusion interacts with economic globalization to foster inclusive growth. Column (4) of Table 7 reveals that a negative interaction effect of ICT and economic globalization, implying that the negative effect of economic globalization on inclusive growth could be mitigated by its interaction with ICT diffusion. The interaction effect of economic globalization and ICT diffusion only results in a −0.0184% less reduced inclusive growth. This validates our earlier results that the interaction effect of ICT and trade openness lessens the negative effect of trade openness on inclusive growth. The region of SSA has seen a decline in goods commerce and finance, while digital flows, which spread knowledge, ideas, and innovation throughout the world and increased involvement in the global economy, are on the rise. The price of international transactions is reduced through digital platforms like Facebook, E-bay, and Alibaba. They develop marketplaces and user communities on a worldwide scale, giving firms access to a sizable pool of potential clients and efficient channels for interacting with them.

5 | CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 | Conclusion

This study examines the interaction among ICT diffusion, FDI, trade openness, economic globalization on inclusive growth while controlling for inflation, vulnerable employment, and social protection over the periods 2005–2020 for 48 SSA countries. The inclusive growth index, like the ICT index, passes all preliminary tests. For empirical analysis, we adopt different estimation methods to investigate the static and dynamic interactive effect of the series on inclusive growth. For the static model, we conduct Breusch–Pagan and Hausman tests to decide on the most consistent and efficient estimators among the pooled-OLS, fixed effects, and random effects. For dynamic model, existing literature suggests that GMM accounts for unobserved heterogeneity and avoids biased estimates when the dependent variable has a time lag. Improving on the existing studies, we conduct model specification exploration as a prerequisite for obtaining an efficient and consistent GMM estimator.

5.2 | Policy recommendations

Based on the empirical results, several policy implications can be drawn to foster inclusive growth in the context of ICT, trade, globalization, FDI, and related control variables. Here are some workable policy implications.

From a policy standpoint, this study is of the opinion that governments and institutions should focus on encouraging the widespread adoption and use of ICT to enhance inclusive growth. This can be done by establishing digital literacy programs, providing subsidies for ICT infrastructure in underserved areas, and supporting technology startups to promote ICT adoption.

Governments should create a conducive environment for FDI by offering incentives and reducing investment barriers, by streamlining investment procedures, providing tax incentives, and ensuring legal protections for foreign investors can attract more FDI. While embracing globalization and trade, policymakers should also consider measures to mitigate potential negative effects on inclusive growth. This can be done by implementing targeted policies to support local industries, ensuring fair trade practices, and providing safety nets for vulnerable populations can help balance the effects of trade and globalization. In addition, measures to control inflation are crucial to maintaining a stable economic environment that supports inclusive growth. Central banks can employ monetary policies, such as adjusting interest rates, to control inflation and stabilize prices.

Efforts should be made to create and promote decent, non-vulnerable employment opportunities. Skill development programs, job training initiatives, and labor market reforms can help transition vulnerable employment to more stable and productive work. Furthermore, strengthening social protection programs can provide a safety net for vulnerable populations, ensuring they benefit from economic growth. This can be achieved by introducing or expanding social welfare programs, such as unemployment benefits, healthcare coverage, and pension schemes, to enhance the well-being of citizens.

Investing in education and skill development aligns with the growth potential of ICT and can empower individuals to participate in the digital economy, by establishing vocational training centers, modernizing curriculum to include digital skills, and providing scholarships for higher education can equip the workforce for the digital age. Policymakers should embrace globalization in a sustainable manner, considering the impacts on local industries, labor, and the environment, by implementing environmental regulations, supporting fair trade practices, and negotiating trade agreements that consider social and environmental factors can lead to sustainable globalization.

Policymakers in this region should develop comprehensive and inclusive digital infrastructure to ensure equitable access to ICT benefits across all segments of society. This can be achieved by building broadband networks in rural and underserved areas, providing affordable internet access, and ensuring digital inclusion for marginalized communities can bridge the digital divide. Lastly, collaboration between governments, private sector, civil society, and

international organizations is crucial for implementing effective policies that promote inclusive growth by establishing public-private partnerships for ICT initiatives, coordinating trade policies with industry stakeholders, and involving civil society in social protection programs can lead to more comprehensive solutions. These policy implications aim to leverage the positive influences of ICT, FDI, and social protection while addressing potential challenges posed by trade, globalization, inflation, and vulnerable employment. Implementing a combination of these policies can create an enabling *environment for sustainable and inclusive economic growth*.

5.3 | Limitation of the study

This study is without limitation. We acknowledge the necessity of placing more emphasis on the rationale behind selecting the 2005–2020 sample period. The extent of available data prior to 2005 for certain SSA countries constrained our ability to extend the analysis further back in time. Moreover, several of the ICD indicators incorporated into our study are not accessible beyond 2020. The decision to opt for the 2005–2020 timeframe stems from its representation of the most comprehensive and balanced panel dataset currently accessible for the countries and variables encompassed in our research. Finally, we are of the opinion that while data limitations can pose challenges, they also present opportunities for creative problem-solving and a deeper understanding of the complexities within research domain.

DATA AVAILABILITY STATEMENT

The data will be made available upon reasonable request.

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ENDNOTES

[1] These table we be provided upon request.

[2] The instruments used to estimate our system GMM models are the lags of the regressors. Additionally, in line with current GMM-centric literature, two key properties of the data drive the selection of the GMM technique. The instruments used to estimate our system GMM models are the lags of the regressors. Additionally, in line with current GMM-centric literature, two key properties of the data drive the selection of the GMM technique (Tchamyou, 2019). (a) More cross sections are present than there are periods in each cross section. (b) There is a strong correlation between the dependent variable's level series and its first lag series.

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APPENDIX A: Correlation matrix for information and communication technology index indicators

	1	2	3	4	5	6	7	8	9	10	11	12	Bartlett test
Secured internet servers (per 1 million people)	1.0000												
Secure internet servers	0.0931	1.0000											
Individuals using the internet (% of the population).	0.2635***	0.2641***	1.0000										
Mobile cellular subscriptions	0.1910**	0.2196***	0.7985***	1.0000									
Mobile cellular subscriptions (per 100 people)	0.3088***	−0.0133	0.2587***	0.2769***	1.0000								
Fixed broadband subscriptions (per 100 people)	0.0417	0.4702***	0.5752***	0.4696***	−0.0530	1.0000							
Fixed broadband subscriptions	0.4892***	0.0255	0.3849***	0.3607***	0.5089***	0.1599**	1.0000						
Fixed telephone subscriptions	0.3114***	0.0023	0.1917***	0.2174***	0.4298***	0.0576	0.6882***						
Fixed telephone subscriptions (per 100 people)	0.0318	0.2149***.	0.5004***	0.4175***	−0.1053	0.7621***	0.1387	0.1670**	1.0000				
Secondary school education (gender parity)	−0.1237*	0.0622	−0.3164***	−0.0785	−0.1636**	0.1298**	−0.1802**	−0.2243***	0.0549	1.0000			
Mean secondary school enrolment in years	0.1610**	0.1078	0.5814***	0.5617***	0.2045***	0.5080***	0.3117***	0.2823***	0.5893***	−0.1227	1.0000		
Tertiary school enrolment (gross)	0.0540	0.0463	0.2142***	0.1822***	0.1511*	0.1418**	0.1422**	0.1381*	0.2475***	−0.1917***	0.3524***	1.0000	
Chi (χ^2) statistic													1061.522***
Chi (χ^2) *p*-value													.0000

Note: *, ** and *** represent significant levels at 0.10, 0.05 and 0.01 percent, respectively.

APPENDIX B: Correlation matrix for inclusive growth index indicators

	1	2	3	4	5	6	7	8	9	10	11	12	Bartlett test
Sanitation	1.0000												
Electricity access	1.0000	1.0000											
Gini index	0.7170***	0.1926***	1.0000										
Education expenditure	0.2985***	0.1847***	0.3081***	1.0000									
Human capital index	0.2292***	0.1265***	0.0397	0.4631***	1.0000								
Health expenditure.	−0.0992*	0.2686***	0.3108***	0.5473***	−0.1153***	1.0000							
Labour	0.4314***	−0.5664***	−0.1169**	−0.0343***	0.0525***	−0.0986*	1.0000						
Clean fuel access	−0.4955***	0.7561***	0.3006***	0.2725***	−0.0575	0.4897***	−0.5245***	1.0000					
Social protection	0.7754***	−0.4349***	−0.4535***	−0.0530	0.2016***	−0.3039***	0.4355***	−0.5848***	1.0000				
Rule of law	−0.5147***	0.4631***	0.2405***	0.5895***	0.0443	0.5600***	−0.1331**	0.5383***	−0.0748*				
Voice and accountability	0.4966***	0.3226***	0.0295	0.5492***	0.0278	0.5090***	−0.1175**	0.3426***	0.0200	0.8000***	1.0000		
GDP per capita	0.2795***	0.6720***	0.2488***	0.0867*	−0.1143***	0.2752***	−0.4790***	0.7102***	−0.6768***	0.3489***	0.1694	1.0000	
Chi (χ^2) statistic													1061.522***
Chi (χ^2) *p*-value													.0000

Note: *, ** and *** represent significant levels at 0.10, 0.05 and 0.01 percent, respectively.
Abbreviation: GDP, gross domestic product.

APPENDIX C: Correlation matrix of the variable

Variable	igr_ind	ict_ind	fdi	net_trad	egi	infl	vul_empl	Net_trad	persrem
igr_ind	1.0000								
ict_ind	0.1789	1.0000							
fdi	0.0247	0.0122	1.0000						
net_trad	0.0446	−0.0800	−0.0874	1.0000					
egi	0.7185	0.2530	0.2127	0.0812	1.0000				
infl	−0.1289	0.0558	−0.0105	0.0017	−0.0448	1.0000			
vul_empl	−0.9220	−0.2746	0.0616	−0.0209	−0.5812	0.0772	1.0000		
soc_prot	0.5733	0.1636	−0.0675	−0.0419	0.3245	−0.0332	−0.6169	1.0000	
persrem	0.0571	−0.0756	−0.0912	0.0792	−0.0106	−0.1039	−0.0800	0.0188	1.0000