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FINANCIAL DEVELOPMENT AND INNOVATION-LED ECONOMIC GROWTH: EMPIRICAL INSIGHT FROM SUB-SAHARAN AFRICA

ABSTRACT: *The body of literature on the nexus concerning innovation, the development of financial systems, and economic growth has gained increasing attention in recent times. However, it is observed that the majority of studies are conducted in developed and emerging economies. This study is unique in its own right by exploring the effect of innovation and financial development on economic growth using panel data for 30 sub-Saharan Africa (SSA) countries from 2001–2018. The study employed symmetric panel ARDL, common correlated effect ARDL, and asymmetric panel ARDL. Our empirical findings revealed a long-run effect of innovation and financial development on the economic growth of SSA. This means that expansion of the financial sector and better innovation activities in SSA stimulate long-term economic growth. Robustness tests provided consistent results with the baseline findings. The study therefore recommends that to promote sustained economic growth and development in the region, policy makers must collectively work in close collaboration with relevant stakeholders in enhancing regional financial reforms and innovative activities.*

KEY WORDS: *economic growth, innovation, financial development, sub-Saharan Africa*

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1. INTRODUCTION

In recent times, theoretical and empirical studies on the nexus between innovation, financial development, and economic growth have attracted attention from academics, policy makers, researchers, and development practitioners. This is because innovation and financial development are believed to be important tools for promoting economic growth and the sustainable development of nations (Abdu & Jibir, 2018; Ho et al., 2018; Mtar & Belazreg, 2020; Santi & Santoleri, 2017; Pradhan et al., 2021). In the literature, there are three strands of studies on innovation and financial development-led growth. The first category consists of the studies that explore the link between innovation and growth (Abdu & Jibir, 2018; Bernier & Plouffe, 2019; Santi & Santoleri, 2017). According to their findings, growth is achieved through scientific discoveries that bring new ideas and knowledge in solving complex problems and providing solutions that promote overall advancement in society.

The second body of literature examines the role of financial development in promoting economic growth. Levine (1997) stresses that financial development remains a prerequisite in solving the problem of underdevelopment. There are several studies that support this postulation – arguing that financial services provide a foundation for future development through the accumulation of capital, technological progress, and capital intermediation (Ang & Kumar, 2014). Broadening and deepening of financial products across the world widened risk preferences and reduced transaction costs, which has led to the expansion of the market and the economies of nations (Pradhan et al., 2014). However, there are studies that show instances when financial development impedes the economic development of nations (Zhu et al., 2020; Levine, 1997). Financial development may lead to a banking crisis and metamorphose into an economic crisis, thereby negatively affecting the economy, including innovation activities (Zhu et al., 2020; Levine, 1997).

The third strand of literature explores the nexus between financial development and innovation. Numerous studies have found that there is a strong positive relationship between innovation and financial development (Trinugroho et al., 2021). Financial development increases the availability of the resources dedicated to the research and development (R&D) sector to promote innovative activities (Ho et al., 2019). A sound financial system helps in assembling resources for R&D

funding and diversifying risks (Trinugroho et al., 2021). In line with this argument, recent literature on financial development-led innovation claims that the financial system promotes innovation programmes through the provision of the services. needed In so doing, it lowers transaction costs and facilitates long-term investment in risky but profitable sectors of the economy (Levine, 1997; Meierrieks, 2014; Tee et al., 2014).

Empirical evidence on the effects of financial development and innovation on growth remains largely conflicting and inconclusive, which calls for further exploration principally in the case of developing countries of Africa. In contrast to studies conducted in developed countries, previous studies of African regions did not combine both innovation and financial development in a single growth model. This exposes the weakness of the previous studies given the strong linkage between innovation and financial development in promoting growth. Zhu et al. (2020) and Laeven et al. (2015) stress that models of economic growth mostly ignore financial development. It was Romer (1990) and Aghion and Howitt (1992) that added to the core models of endogenous technological change. In the innovation-led growth hypothesis, it is paramount to know that financial development determines how best society distributes funds to firms and households. Aghion et al. (2005) posit that variations in financial development remain a crucial factor in influencing the allocation of resources to innovative activities for businesses.

Thus, the debate in this area continues to attract attention, especially in developing countries, which are constantly under pressure to enact policies supporting job creation, innovation and scientific discoveries, and societal welfare, with this pressure having only intensified in recent times. Thus, this study aims to conduct an anatomy of innovation and financial development-led growth within the context of sub-Saharan Africa (SSA).

Sub-Saharan Africa remains the poorest region in the world. According to the World Bank (2021), up to a remarkable 48.5% of the people in SSA are living on less than $1.25 per day. Despite this disturbing statistic, the future development of the region remains bright as the gross domestic product per capita for 2021 stood at $1,645 million, which shows an increase of 9.57% compared to the previous year (World Bank, 2021). In addition, SSA nations have, in recent years, undertaken financial, trade, and political reforms – which is assumed to have meaningfully enhanced their financial systems and innovative activities (Bekana, 2021; Jibir et al., 2019). A study of this nature is therefore critical in order to explore the underlying linkages between financial development, innovation, and economic growth of the region. It is therefore believed that the outcome of this study would serve as an indispensable element for designing better developmental agenda for the region. This research is appropriate given that an overhaul of the financial system and an innovative approach to business models has lately been acknowledged and emphasised by the policy makers in SSA as part of their efforts to achieve goals 8 and 9 of the United Nations Sustainable Development Goals (SDGs).

This study hopes to make three specific contributions. First, this paper complements the existing literature that focuses on economic growth and development in sub-Saharan Africa. It adds to the body of knowledge in this area, as prior results are mixed (Galindo & Mendez; 2014; Hsu et al., 2014). Second, it is a truism that African countries lag behind other regions in terms of commitment to innovative and financial reforms. In contrast to some regions, such as East and South Asia, which have made a significant commitment to R&D and other reforms in their financial sector, Africa remains the most backward region in terms of innovation and financial development. Within the continent, sub-Saharan Africa deserves special attention. Thus, this study focuses on SSA to explore the nexus between innovation, financial development, and growth. These variables, to the best of our knowledge, have not been examined simultaneously in previous studies. In addition, we apply more than one methodological framework and a large number of SSA countries that have not been investigated in this manner in previous studies. This is used to ensure robustness and provide better findings for policy prescription.

The remainder of the paper is structured in the following ways. Section 2 provides a robust review of literature. Section 3 anchors the data and methodology. Data analysis and interpretation are carried out in section 4 and the last section concludes the paper.

2. REVIEW OF LITERATURE AND HYPOTHESIS DEVELOPMENT

2.1. Innovation and Economic Growth

Schumpeter (1912) pioneered studies on the nexus between innovation and long-run economic growth. He contends that a perfectly competitive equilibrium refers to a situation whereby an economy is stationary and there is an absence of profits, interests, investments, and involuntary unemployment. The equilibrium is thus analogous to a circular flow in which the same products are continuously manufactured utilising the same technology, and the process perpetuates itself until economic development occurs. Economic development occurs due to 'carrying out of new combinations'– referring to innovations (Schumpeter, 1912). Profit-seeking entrepreneurs are the main source of innovations through *creative destruction* (Schumpeter, 1942; Aghion & Howitt, 1992). Creative destruction is a kind of business cycle, whereby nations experience economic expansion as entrepreneurs innovate and the innovations are widely imitated. However, if the existing products or services are out of fashion, economic downturn sets in; entrepreneurs go back to the drawing board to innovate again. The economy contracts because it takes time for the innovation to be widely spilled over to other sectors.

Both exogenous and endogenous growth theorists all agree that innovation and, by the same token, technological progress remain the key factor driving long-term economic growth (Aghion & Howitt, 1992; Romer, 1986; Cass, 1965; Solow, 1956). While Solow and his followers are of the view that technological progress is determined outside the growth models, Romer and other endogenous growth theorists argue that technological progress is endogenously determined. Romer (1990) asserts that technological progress comes about as people respond to market incentives to make monopolist profits, and as a result, they invest huge resources to produce technical knowledge. These investments include private expenditure on R&D and human capital investment. The stock of R&D and human capital determines the capacity of enterprises to produce new knowledge. Thus, technological progress is endogenous.

Still, according to Romer (1990), *non-rivalry* and *non-excludability* are the essential properties of scientific knowledge or technology. Technological progress is non-rival as the cost of utilising it continuously is negligible, even zero at the extreme. Once new knowledge is produced, 'it can be used as often as desired' (p.4) at very small additional cost relative to the costs of producing the knowledge. Technological change is partially non-excludable given that innovators cannot easily prevent other people from copying or imitating new knowledge. Romer (1990) concludes that a production function with technology as one of its inputs cannot be a constant-return-scale function, that is, the function is not convex. Thus, technology contributes to long-term economic growth by increasing the productivity of innovative firms and through the spill-over effect on other sectors.

Given the robustness and popularity of endogenous growth theories, there are burgeoning studies empirically exploring the association between innovation and economic growth across countries. These studies utilise different proxies of innovation, including R&D efforts, patent applications and grants, citations of science and technical journal papers, high-tech exports, and many more. Ultimately, there are 3 distinct bodies of studies analysing the relationship between innovation and economic growth. The first body provides evidence that innovation impacts economic growth *directly*. Pece et al. (2015), focusing on three Central and Eastern European countries for the period 2000–2013, discover that R&D efforts and the number of registered patents and trademarks spur economic growth. Conversely, Gyedu et al. (2021) report that innovation is negatively significant in G7 countries while only R&D is positively significant in BRICS (Brazil, Russia, India, China, and South Africa). Sesay et al. (2018) argue that the national innovation system (NIS), instead of fragmented innovation of business entities, remains fundamental to promoting broad-based economic growth. They demonstrate this empirically using BRICS data for the period 2000–2013.

In a country-specific study, Law et al. (2020) find that patent applications discourage economic growth while patent grants promote the Malaysian economy, implying that quality (not the quantity of) innovation is vital to economic growth in Malaysia. Similarly, Jian et al. (2021), using a GMM estimator on 1978–2017 data for Chinese provinces, find that patent grants are directly responsible for differences in regional economic growth. Wang et al. (2022), based on 2011–2019 data for 31 provinces and cities in China, find that both financial innovation and technological innovation (R&D and patent applications) promote economic growth. Finally, Nazir et al. (2021), using the

ARDL model on 1970–2016 data for China, India, and Pakistan, show that financial innovation boosts economic growth across all the periods.

The second body of literature claims that the innovation-growth link is not a black-box sort of relation. Innovation affects economic growth conditioned by other factors such as institutions, social filters, human capital, etc. Countries endowed with strong institutions tend to be more innovative as the institutions increase the incentives to innovate, and high innovative capacity results in high economic performance (Bekana, 2020; Hadfield, 2008; Kiertisak, 2016). For sub-Saharan African and European countries, respectively, Bekana (2020) and d'Agostino and Scarlato (2018) confirm that quality institutions guarantee equal opportunities and raise the incentive to innovate. This amplifies the exogenous impact of the knowledge base on economic growth accordingly. Akcigit et al. (2023) develop a theoretical model of the links between political connections, innovation, and economic growth. They analyse Italian data for the period 1993–2014 and demonstrate that political connections impede innovations through the low entry of innovative firms and reallocation, which ultimately reduces economic growth. Innovation as conditioned by financial development (Fagiolo et al, 2020), human capital (Cinnirella & Streb, 2017), and social filters represented by urbanisation, social capital, privatisation etc. (Xiong et al., 2020) promotes economic growth.

The third body examines causal relationships between innovation and economic growth. Within this strand of literature, some studies find evidence in line with the hypothesis that innovation Granger-causes economic growth (Maradana et al., 2017; Pradhan et al., 2018; Pradhan et al., 2021, Sarangi, et al., 2022). Some other studies confirm that as economies grow and become richer, they raise their investment in R&D and, thus, their innovative capacity improves (Avila-Lopez et al., 2019). While Avila-Lopez et al. (2019) and Kurniawati (2020) observe feedback causality between innovation and economic growth, Mtar and Belazreg (2021) find no causality between them.

Based on the literature review, it is clear that innovation impacts economic growth positively by raising the productivity of labour and capital inputs as well as by means of knowledge spillovers to other sectors. However, there is evidence of reverse causality between them as affluent economies can afford to invest heavily in research and development or science and technology to improve their innovative capacity. Again, the effect of innovation on economic growth is conditioned on other factors

***H_1**: Innovation enhances economic growth through productivity improvements of traditional inputs of capital and labour.*

2.2. Financial Development and Economic Growth

It was Schumpeter (1912), then Goldsmith (1969) and Hicks (1969) who first provided a more sophisticated theoretical discourse on the connection between finance and economic growth. Schumpeter contended that financial intermediaries, instruments, and markets make resource allocation highly efficient by identifying and funding entrepreneurs with innovative ideas. Thus, finance spurs economic growth and development through technological innovation. John Hicks (1969) extended Walter Bagehot's argument that a good financial system triggered off industrialisation in England via capital mobilisation for productive projects. In addition to the efficient allocation of resources, Banerjee and Newman (1993) claim that financial systems curtail income inequalities and increase the fortunes of less-wealthy individuals, thereby submitting that easing credit constraints in the system could accelerate economic growth. Aghion et al. (2010) also theorise that efficient financial systems facilitate economies to weather financial crises effectively by minimising macroeconomic volatility. By easing credit constraints, financial systems empower firms to borrow and invest wisely, especially during economic downturns when it is cheap to borrow and collateral values are also low. Hence, efficient and developed financial systems enhance economic growth and, at the same time, streamline countercyclical investments, which neutralise the severity of economic fluctuations (Aghion et al., 2018).

In summary, Levine (2005) highlights and discusses five major mechanisms through which financial systems boost economic growth: generating information and capital allocation, monitoring firm's activities, risk minimisation, increasing savings, and enabling exchange. Nevertheless, Lucas (1988) counter-argues that finance is an overemphasised driving force of economic growth and argues that labour, capital, and technical progress are the fundamentals of economic growth and development.

On the empirical front, there are therefore three strands of literature in this area. The first body of literature establishes evidence that financial development indeed spurs economic growth. Yang (2018) consistently observes that financial development significantly promotes output growth across low, middle, and high-income countries through physical capital and technical progress channels. Similarly, Abeka et al. (2021), Ehigiamusoe (2021), and Olayungbo and Quadri (2019), focusing on sub-Saharan Africa, find that finance strongly stimulates output growth in the region. Abeka et al. (2021) further observe that the effect is larger on economies with stronger telecommunication infrastructure.

In a country-specific study, Olorogun et al. (2020) find evidence that finance leads to output growth by applying the ARDL model to Nigerian data (1978–2018). In the same vein, Nguyen et al. (2022) and Sarwar et al. (2020) discover that financial development has a linear and positive effect on growth of output in emerging market economies. Again, studies on Latin American and European countries show that financial crises checkmate the impact of finance on output growth (Asteriou & Spanos, 2019; Santana, 2020). Regarding Asian countries (China, Japan, India), Wu et al. (2020) find that financial development matters greatly in their respective economic growth process.

The second body of literature shows that financial development retards output growth. Irrespective of national income level, Cheng et al. (2020) show that financial development has been persistently negative in influencing economic growth. They construct and apply a composite index of financial development. They further argue that inefficient financial systems result in speculation, lower investment, and misallocation of resources. Likewise, Rahman et al. (2020), using the Markov switching methodology and the composite index of financial development, discover that financial development negatively affects economic growth.

The last strand of literature claims that financial development is asymmetrical or non-linear in influencing economic growth, that at some points the effect is positive while at other points the effect is negative. For example, Chen et al. (2020), using NARDL, find evidence in Kenya that positive changes in financial development boost economic growth in the short run and negative changes dampen economic growth in the long run. These studies conclude that the impact of financial development on economic growth is conditioned by the pattern of shocks to the financial sector.

From the preceding literature review, there is much evidence that financial development promotes output growth irrespective of the region or national income level. However, the composite measure of financial development tends to exert negative impacts on output growth.

***H_2**: Financial development spurs economic growth through physical and technological progress.*

3. METHODOLOGY

3.1. Data Sources and Variables

This study collects the data for the period 2001–2018 for 30 sub-Saharan Africa countries. The choice of countries and period is determined by data availability and the sub-regional distribution of the countries. This study used annual data collected from the WDI (World Development Indicator) of the World Bank data base (World Bank, 2021). Economic growth is taken as a dependent variable and is measured by GDP per capita (current US$). Moreover, there are several studies based on innovation, but the literature does not directly specify a single indicator or proxy for innovation. Several studies (Hsu et al., 2014; Pradhan et al., 2018) measure innovation differently using different measures. However, other studies observed that the proxies have many shortcomings (Thomson, 2009; Moser, 2013). Some researchers argue that productivity growth is a good approximation of innovation. The proposition of Jorgenson (2011) on innovation has been empirically validated by Hall (2011). In Table 1, we define the variables and show their units of measurement and sources of the data.

Table 1: Variables, Measurement and Sources of Data

	Variables	Measurement	Source
Dependent Variable	Economic Growth	GDP per capita (current US $)	WDI of the World Bank
Independent variables	Innovation	Citation index of scientific and technical journal articles	WDI of the World Bank
	Financial Development	Share of Private Credit to GDP	World Bank Financial Structure Database.
Control Variables	Trade Openness	Import plus export as a share of GDP	WDI of the World Bank
	Capital Stock	Capital stock as a percentage of gross domestic product	WDI of the World Bank

Source: Authors' construction

Fazlioĝlu et al. (2019) used different proxies for innovation (product, process, and organisational). Looking at innovation from a different angle, Bekana (2021) measures innovation using the citation index of scientific and technical journal publications. Following the approach of Bekana (2021), we use the citation index of scientific and technical journal publications as a proxy for innovation. We also use domestic credit to the private sector (percentage of GDP) to represent financial development, which was previously applied by several studies (Ang et al., 2010; Ang & Kumar, 2014; Baltagi et al., 2009; Zhu et al., 2020). Several other factors are likely to influence growth, including trade openness and capital stock as a percentage of GDP (Grossman & Helpman, 1990; Romer 1990; Young, 1991, Jibir et al., 2018; Cooke, 2010). Following the previous studies, we take the share of total trade (percentage of GDP) as a proxy for trade openness and gross capital formation (percentage of GDP) for capital stock.

3.2. Empirical Model Specification and Estimation Techniques

To empirically investigate the connection between innovation, financial development, and GDP per capita, we set up a baseline model in which innovation and private credit as a share of GDP determine the countries' GDP per capita over the years. Consistent with the previous literature, equation (4) specifies our empirical model:

$$GDPPerK_{it} = \alpha_0 + \beta_1 Innovat_{it} + \beta_2 FinDevt_{it} + \beta_3 TradOpen + \beta_4 Capital_{it} + \varepsilon_{it} \qquad (1)$$

where $GDPPerK_{it}$ is GDP per capita (current US$), which is the proxy for economic growth; $Innovat_{it}$ stands for innovation; $FinDevt_{it}$ represents financial development; $TradOpen_{it}$ is trade openness; $Capital_{it}$ is the capital stock; ε_{it} is an error term; and β represents the parameters to be computed, all for country *i* at time *t*.

Our estimation strategy follows these sequential stages. After data cleaning, we first test the presence of cross-sectional dependence (CD), and then apply the second generation panel unit root to test the level of integration for each variable. If none of the variables is stationary at second difference, I(2), we then check for long-run relationships between the variables using panel co-integration tests, such as the Pedroni and the Kao panel co-integration tests. Given the possibility of a combination of I(0) and I(1), we finally apply panel autoregressive distributed lag (ARDL) estimators to check the short-run and long-run effects of innovation and financial development on economic growth. This is especially the case when a long-run relationship is detected.

The panel data is analysed using a panel autoregressive distributed lag (ARDL) model with three estimators – mean group (MG), pooled mean group (PMG) and dynamic fixed effect model (DFE) estimation. These estimators are applied to examine the short-run and long-run association between innovation, financial development, and economic growth. The MG estimator gives room for heterogeneity in the short- and long-run relationships and this estimator is appropriate for a large sample as it is sensitive to permutations and outliers (Pesaran et al., 1999). In contrast, the PMG estimator limits long-run relationships to being homogenous across all units but allows heterogeneous short-run relationships. Finally, the DFE estimator, which is usually a two-way effect, restricts the error correction, slope coefficient, and short-run coefficient to demonstrate non-heterogeneity across the units (Baltagi et al., 2000). Following the available literature on panel data, we use the mean group and the pooled mean group to select the appropriate estimator between MG, PMG and DFE. We use the Hausman test to see if there are any significant differences between these estimators. Equation (2) specifies the panel ARDL (m, n) model as proposed by Pesaran et al. (1999):

$$\mathrm{y}_{it} = \sum_{j=1}^{m} \gamma_{ij} y_{it-j} + \sum_{j=0}^{n} \vartheta_{ij}^{'} x_{it-j} + \mu_{it} \tag{2}$$

In equation (2), subscript $i = 1, 2, \ldots, N$ represents the country, $t = 1, 2, \ldots, T$ represents the periods, m serves as the number of lags for the dependent variable and n is the lag number of the independent variables, where y_{it-j} represents a $k\times 1$ vector, ϑ_{ij} serves as a $k\times 1$ co-efficient vector, μ_t is error term and γ_{ij} represents a vector of scalars. By parameterising equation (2), we derive the error correction form as in equation (3):

$$\mathrm{dy}_{it} = \phi_i \mathrm{y}_{it-1} + \beta'_i x_{it} + \sum_{j=1}^{m-1} \gamma_{ij}^{*}\, d\mathrm{y}_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'}\, dx_{it-j} + \mu_{it} \tag{3}$$

Equation (4) is a re-specification of equation (3):

$$\mathrm{dy}_{it} = \phi i\ (\mathrm{y}_{it-1} - \theta'_i x_{it}) + \sum_{j=1}^{m-1} \gamma_{ij}^{*}\, d\mathrm{y}_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'}\, dx_{it-j} + \mu_{it} \tag{4}$$

where $\theta_i = -\beta_i/\phi_i$ is the long-run relationship between y_{it} and x_{it} while γ_{ij}^* and ϑ_{ij} show the short-run coefficient of y_{it} and x_{it}. The term ϕ_i represents the error-correction coefficient, which is used in the equation to measure the speed of adjustment of y_{it} due to a change in x_{it}. Should the effect be negative, this represents convergence to long-run equilibrium. However, if ϕ_i is found to be positive, it means that the equilibrium does not converge in the long run, which further indicates that there is no long-run relationship in the model.

Given the possibility of CD in the panel data, we introduce a common correlated effect to account for contemporaneous correlation. By creating and incorporating indicators of weighted cross-sectional averages of regressors into MG and PMG, we compute the common correlated effect mean group (CCEMG) and the common correlated effect pooled mean group (CCEPMG), respectively (Pesaran, 2006).

As a robustness check, we also estimate asymmetric or non-linear panel ARDL models as recommended by Shin et al. (2014) to check the asymmetric response of long-run and short-run changes in innovation and financial development in economic growth. By decomposing the changes in variables of interest into positive change (d^+) and negative change (d^-), we specify asymmetric panel ARDL estimators in equations (5) and (6).

$$y_{it} = \phi_i y_{it-1} + \sum_{j=1}^{m-1} \gamma_{ij}^{*} dy_{it-j} + \sum_{j=0}^{n-1} \vartheta_{ij}^{*'} (d_{it-j}^{+} + d_{it-j}^{-}) + \sum_{j=0}^{n} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (5)$$

By re-parameterising equation (5), we derive equation (6):

$$\Delta y_{it} = \phi i \left[y_{it-1} - \theta'_i (d_{it-j}^{+} + d_{it-j}^{-}) - \theta'_i x_{it} \right] + \sum_{j=1}^{m-1} \vartheta_{ij}^{*} \left(d_{it-j}^{+} + d_{it-j}^{-} \right) +$$
$$\sum_{j=0}^{n-1} \vartheta_{ij}^{*'} dx_{it-j} + \mu_{it} \quad (6)$$

4. RESULTS AND DISCUSSION

4.1. Summary Statistics of Variables and Correlation Analysis

Table 2a contains the summary statistics with natural log GDP per capita representing economic growth, scientific and technical journal articles standing for innovation and private credit as a proportion of GDP serving as financial development. The table reports the descriptive statistics for total trade as a share of GDP, which is a proxy of trade openness, and capital stock measured by gross capital stock as a percentage of GDP.

Table 2a: Summary Statistics of Variables

Summary	Economic Growth	Innovation	Fin. Devt.	Trade Open	Gross Capital
Mean	7.0047	4.7225	3.5159	4.4274	3.7698
Maximum	9.7369	9.4750	4.5290	5.5043	4.6064
Minimum	4.8877	3.0395	3.0506	3.0920	3.0829
Std. Dev.	1.0292	1.4297	0.2857	0.3939	0.2094
Skewness	0.6035	1.1930	0.9567	0.2281	0.3510
Kurtosis	2.7980	4.1239	3.6453	3.4918	3.7160

Source: Authors' computation using Stata 17.0

The mean value of economic growth is the highest, followed by those of innovation, trade openness, gross capital stock, and financial development. Except for economic growth, which is mesokurtic, all of the variables are positively skewed and leptokurtic. Table 2b signifies that there is a weak correlation between the variables as the correlation coefficients are considerably below 0.30.

Table 2b: Pairwise Correlation Analysis

Summary	Economic Growth	Innovation	Fin. Devt.	Trade Open	Gross Capital
Economic Growth	1				
Innovation	0.230	1			
Fin. Devt.	0.203	-0.140	1		
Trade Open	0.100	-0.065	0.106	1	
Gross Capital	0.157	-0.117	0.1167	0.049	1

Source: Authors' computation using Stata 17.0

The table shows the highest correlation coefficient is between innovation and economic growth (0.230), followed by that between financial development and economic growth (0.203). This means there is no possibility of multicollinearity.

4.2. Cross-Sectional Dependence Test

In Table 3, we show the results of the CD tests, Breusch-Pagan LM, Pesaran scaled LM, bias-corrected scaled LM, and Pesaran CD, in which all the variables are significant at the 1% level of significance.

Table 3: Cross-sectional Dependence Test

Series	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
Economic Growth	5803.88***	182.02***	181.14***	75.65***
Innovation	4660.05***	143.24***	142.36***	64.74***
Fin. Devt.	3180.04***	93.07***	92.18***	35.05***
Trade Open	1841.44***	47.68***	46.80***	5.70***
Gross Capital	1367.48***	31.61***	30.73***	8.85***

***, **, * show the significance level at 1%, 5% and 10%, respectively

Hence, we reject the null hypothesis of no cross-sectional dependence. The presence of cross-sectional dependence suggests that the second generation unit root tests are the most appropriate.

4.3. Second Generation Unit Root Test

In Table 4, the second generation unit root test using cross-sectional Im-Pesaran (CIPS) as propounded by Im, Pesaran and Shin (2003) and cross-sectional augmented Dickey-Fuller (CADF) show that two out of the five variables are non-stationary at a level I(0) but become stationary after taking their first difference, I(1). Economic growth, innovation, and gross capital are stationary at level, i.e. I(0), whereas financial development and trade openness become stationary after taking the first difference, i.e. I(1). Therefore, the panel ARDL model is suitable for a mixed level of integration. Thus, we apply the panel ARDL approach to explore the long-run and short-run impacts of innovation and financial development on economic growth.

Table 4: Second Generation Unit Root Test

Variables	CIPS		CADF	
	I(0)	**I(1)**	**I(0)**	**I(1)**
Economic Growth	-2.654***	----	-2.196**	----
Innovation	-3.070***	----	-2.220**	----
Fin. Devt.	-2.119*	-3.884***	-1.982	-2.664***
Trade Open	-1.545	-3.951***	-1.323	-2.829***
Gross Capital	-2.406***	----	-2.376***	----

***, **, * show the significance level at 1%, 5% and 10%, respectively.

4.4. Panel Co-integration Results

The Pedroni and Kao tests are the two variants of panel co-integration tests shown in Table 5. In both tests, the null hypothesis is that there is no co-integrating relationship. The p-value is found to be significant in both tests, suggesting rejection of the null hypothesis of no co-integrating association. As a result, the results indicate the existence of a co-integrating connection between economic growth and the independent variables incorporated in the model.

Table 5: Panel Co-Integration Test

	Pedroni				Kao		
	Statistics	**p-Value**	**Weighted Statistics**	**p-Value**		**Statistics**	**p-Value**
Panel PP-Statistic	-2.6535	0.004	-3.08499	0.001	ADF	-5.118897	0.000
Panel ADF-Statistic	-1.7366	0.0412	-1.84049	0.0328			
Group PP-Statistic	-3.6162	0.0001					
Group ADF-Statistic	-2.5818	0.0049					

Source: Authors' computation using Stata 17.0

4.5. Dynamic Panel Autoregressive Distributed Lag (ARDL) Models

In Table 6, Panel A provides the results of innovation-growth models, where innovation clearly impacts output growth in both the short and long runs. Innovation is only significant in the long run of the DFE model. Given that ECM is negative and significant in all the models under Panel A, innovation alongside the control variables jointly leads to economic growth in the long run. Panel B in Table 6 indicates that financial development is only statistically significant but negative in the PMG model, suggesting that a quality financial system retards economic growth in the long run.

Table 6: Panel Autoregressive Distributed Lag (ARDL) Models

		Panel A			Panel B			Panel C		
	Variable	**MG**	**PMG**	**DFE**	**MG**	**PMG**	**DFE**	**MG**	**PMG**	**DFE**
	Innovation	0.175	0.020	0.337***				0.694**	0.110	0.408***
		(0.323)	(0.120)	(0.104)				(0.326)	(0.111)	(0.118)
	Fin. Devt.				0.060	-0.646**	0.004	-1.771**	-0.931***	-0.335
					(0.994)	(0.282)	(0.323)	(0.786)	(0.302)	(0.275)
Long Run	Trade Open	-0.238	0.494***	0.301	0.016	1.135***	0.337	-0.195	1.099**	0.336*
		(0.695)	(0.189)	(0.187)	(1.080)	(0.173)	(0.250)	(0.473)	(0.175)	(0.19)
	Gross Cap.	-0.105	0.441**	-0.139	5.029*	0.784***	-0.153	0.278	0.816***	-0.187
		(0.828)	(0.172)	(0.257)	(2.722)	(0.122)	(0.342)	(0.619)	(0.118)	(0.262)
	Constant	0.068	0.621	0.982***	0.338	0.279***	0.988***	0.792	0.367***	1.146***
		(0.921)	(0.068)	(0.239)	(0.910)	(0.044)	(0.267)	(0.977)	(0.054)	(0.271)
	ECT	-0.353***	-0.185***	-0.202***	-0.31***	-0.169***	-0.154***	-0.465***	-0.167***	-0.2***
		(0.047)	(0.021)	(0.024)	(0.050)	(0.023)	(0.018)	(0.062)	(0.025)	(0.024)
	Innovation	0.115	-0.032	0.075				-0.145*	-0.013	0.003
		(0.102)	(0.070)	(0.049)				(0.087)	(0.07)	(0.05)
Short Run	Fin. Devt.				0.178	-0.156	-0.099	0.147	-0.06	-0.062
					(0.201)	(0.159)	(0.072)	(0.165)	(0.187)	(0.071)
	Trade Open	0.079	0.046	0.088	0.166	0.070	0.069	0.076	-0.137	0.013
		(0.123)	(0.087)	(0.060)	(0.147)	(0.086)	(0.061)	(0.109)	(0.087)	(0.062)
	Gross Capital	0.257	0.267***	0.022	0.282**	0.310***	0.019	0.007	0.131	0.05
		(0.164)	(0.097)	(0.061)	(0.126)	(0.098)	(0.062)	(0.125)	(0.092)	(0.061)
	CD	33.61***	64.68***	45.45***	7.55***	52.53***	1.19	6.04***	-4.93***	32.15***
	Resid	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
	AR	33.07***	321.2***	30.87***	23.14***	117.4***	37.73***	43.29***	116.73***	43.68***
	Haus.							11.65***		9.08*

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively. **Source**: Authors' computation using Stata 17.0

However, the long-run effects of financial development in the MG and DFE models are positive but insignificant. Similar to innovation-growth models, financial sector development alongside the control variables jointly leads to economic growth in the long run since the ECT is negatively significant in all the models.

Concerning Panel C in Table 6, innovation and financial development have no significant effects on output growth in the short run for the MG, PMG, and DFE models. In the long run for the MG model under Panel C, however, innovation and financial development significantly affect economic growth. While innovation is positively significant, financial development is negatively significant in the model. Financial development is negatively significant in the PMG model as against the positive and significant innovation in the PMG and DFE models under Panel C. All the variables in the models under Panel C jointly promote economic growth in the long run for the SSA region given the negative significance of the ECT in the models. The models under Panel C have further confirmed that innovation matters more than financial development in boosting the economic growth of the SSA countries, especially in the long run.

To find out which model is more efficient under Panel C, we conduct Hausman tests and the results are reported in Table 6. The PMG model is more efficient than the MG model but the DFE model is the most efficient among them since the results are statistically significant. We conduct cross-sectional dependence tests for all the residuals of the models and the results confirm the presence of cross-sectional dependence in all but the DFE model under Panel B. This could make the results biased unless the cross-sectional issue is addressed. This means the ARDL framework in Table 6 overlooks contemporaneous correlation across countries occasioned by unobserved factors. This could render the parametric and non-parametric estimators inconsistent. To address the problem of cross-sectional dependence, we estimate panel ARDL models with common correlated effects and Table 7 reports the results.

4.6 Panel ARDL Models - with Common Correlated Effect

Table 7 reveals the common correlated effect PMG (CCEPMG) and common correlated effect MG (CCEMG) estimates for innovation, financial development, and the combined models. Under Panel A, the CCEMG signifies that innovation has positive and significant short- and long-run effects on GDP per capita. The CCEPMG model under Panel A in Table 6 also indicates that innovation has positive but insignificant impacts on the GDP per capita in both the short and long runs. Interestingly, the error correction terms in all the models, irrespective of panels, are negatively significant at 1%, suggesting that the models converge to the long-run equilibria even if there is any disturbance. Panel B in Table 6 also shows that financial development enhances economic growth in the short and long runs of the CCEMG model, but it is only significant in the long run. In contrast, the CCEPMG estimator demonstrates that financial development retards economic growth irrespective of the periods, but it is insignificant in all the periods.

In Table 7, CCEMG estimates under Panel C indicate that innovation spurs economic growth in both short and long terms, but it is only significant at 1% in the short run. The estimates also report that financial development has positive and negative but insignificant effects in the short and long runs, respectively. Similarly, the CCEPMG estimator under Panel C finds that innovation enhances economic growth insignificantly across the periods. Conversely, the CCEPMG estimator finds that financial development is consistently negative, albeit only significant in the short run, in influencing GDP per capita. None of the control variables is observed to be significant in determining economic growth. Across all the estimations in all the panels, residual tests confirm that the residuals are I(0), implying that the commonly correlated effect estimators are valid even if there is a serial correlation in the error term (Pesaran, 2006).

Table 7: Panel ARDL Models - with Common Correlated Effect

		Panel A		Panel B		Panel C	
	Estimator	**MG**	**PMG**	**MG**	**PMG**	**MG**	**PMG**
	Variable						
Long Run	Innovation	1.140**	0.132			0.364	0.061
		(0.449)	(0.155)			(0.475)	(0.225)
	Fin. Devt.			1.478*	-0.187	-0.131	-0.387
				(0.871)	(0.133)	(1.498)	(0.441)
	Trade Open	-0.293	-0.062	-0.641	-0.081	1.339	-0.113
		(0.514)	(0.231)	(0.422)	(0.053)	(1.163)	(0.258)
	Gross Capital	0.506	0.046	0.066	-0.055	2.644	-0.014
		(0.591)	(0.173)	(0.483)	(0.054)	(1.668)	(0.179)
	Constant	-32.131	0.925	-3.249	-0.247	-15.238**	-0.448
		(24.137)	(2.145)	(5.208)	(1.675)	(7.557)	(1.714)
Short Run	Error Corr. Term	-0.878***	-0.844***	-.963***	-0.795***	-0.925***	-0.812***
		(0.182)	(0.118)	(0.149)	(0.120)	(0.165)	(0.157)
	Innovation	0.280***	0.009			0.413***	0.001
		(0.084)	(0.033)			(0.146)	(0.037)
	Fin. Devt.			0.376	-0.160	0.291	-0.292**
				(0.242)	(0. .312)	(0.325)	(0.146)
	Trade Open	-0.029	-0.050	0.197	-0.091	0.004	-0.089
		(0.160)	(0.069)	(0.190)	(0.211)	(0.345)	(0.079)
	Gross Capital	-0.003	0.019	-0.035	-0.085	-0.176	0.001
		(0.140)	(0.070)	(0.150)	(0.126)	(0.239)	(0.071)
CD		4.05[0.000]	2.73[0.006]	9.07 [0.000]	2.88 [0.004]	2.01 [0.045]	3.22[0.001]
AR		11.366***	21.953***	4.049**	19.094***	5.993**	4.611***
Residual		I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
RMSE		0.11	0.10	0.11	0.11	0.12	0.10
R-Squared		0.44	0.45	0.46	0.47	0.32	0.38
Observations		510	510	510	510	510	510

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

Source: Authors' computation using Stata 17.0

Nonetheless, all the common correlated effect estimators in Table 6 still suffer cross-sectional dependence. Chudik and Pesaran (2015: 14) posit that for commonly correlated effect estimator(s) to be valid two conditions should be met: "a sufficient number of lags of cross-sectional averages must be included in individual equations, and the number of cross-sectional averages must be at least as large as the number of unobserved common factors." Our dataset has met the first condition, but we find it difficult to meet the second condition, as including more lags of averages renders our models inestimable due to relatively small sample sizes. Overall, the estimates point to the beneficial impacts of innovation on economic growth as expected but give us conflicting findings on the effect of financial development.

4.7. Dynamic Panel Autoregressive Distributed Lag (ARDL) Models with Moderator

To see the combined effect of innovation and financial development, we have created a new variable by interacting innovation with financial development (INNO*FIN.DEVT) as in Table 8. Before the interaction, we created centred variables (mean of the variable minus variable) for innovation and financial development, then multiplied the centred innovation and centred financial development. Table 8 shows the results of the dynamic panel ARDL model by including moderation of innovation and financial development. The finding indicates that the interaction term has no impact on economic growth in the long run, whereas in the short run the term has a significant and positive impact on economic growth at the significance level of 10% for the mean group model and 1% for the dynamic fixed effect model. The Hausman test between the MG, PMG, and DFE models rejects the null hypothesis of the efficiency of the PMG and DFE models. Thus, based on the Hausman test, the MG model, in which innovation and financial development jointly affect the economic growth in the short run for SSA countries, is the accepted model.

Table 8: Panel Autoregressive Distributed Lag (ARDL) Models with Moderator (INNO*FIN.DEVT)

	Estimator	MG	PMG	DFE
	Variable	**Coefficient**	**Coefficient**	**Coefficient**
Long Run	INNOVATION	1.700	0.061	0.459***
		(1.562)	(0.067)	(0.108)
	FIN. DEVT.	-3.757	-0.160	-0.290
		(3.334)	(0.179)	(0.249)
	TRADE OPEN	-1.381	0.180*	0.339**
		(1.239)	(0.107)	(0.174)
	GROSS CAPITAL	-0.919	-0.162	-0.231
		(0.539)	(0.154)	(0.244)
	INNO*FIN.DEVT	-0.221	0.072	-0.079
		0.539	(0.062)	(0.025)
Short Run	ECT	-0.620***	-0.070***	-0.218***
		(0.086)	(0.025)	(0.025)
	INNOVATION	-0.055	-0.001	-0.005
		(0.140)	(0.195)	(0.050)
	FIN. DEVT.	0.004	-0.068	-0.058
		(0.081)	(0.082)	(0.070)
	TRADE OPEN	0.029	0.052	0.027
		(0.042)	(0.045)	(0.061)
	GROSS CAPITAL	-0.022	0.022	0.054
		(0.073)	(0.055)	(0.061)
	INNO*FIN.DEVT	0.202*	-0.200	0.081***
		(1.114)	(0.165)	(0.025)
	Cons	4.600***	0.502***	1.139***
		(0.812)	(0.193)	(0.268)
Hausman test b/w MG vs PMG		Chi-square test value 32.821***		
Hausman test MG vs DFE		Chi-square test value 3351.686***		

Note: Value in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

4.8. Robustness Check: Asymmetric Panel ARDL

Given the inconsistent effects of financial development on economic growth, we conduct a panel non-linear ARDL analysis on the dataset as we suspect asymmetric effects of financial development in the models. Table 9 provides the results on the asymmetric effects of financial development and innovation on economic growth in the sub-Saharan African sub-region. The estimators in the table fail to differentiate the asymmetric links between changes in innovation and financial development across the periods. The coefficients of innovation (+) and innovation (-) exhibit a positive sign except in the short run of PMG, where the coefficients are negative. However, the coefficients of financial development (+) and financial development (-) show a negative sign. This suggests that both the negative and positive aspects of innovation exert a positive effect on GDP per capita, whereas GDP per capita responds to positive and negative shocks of financial development negatively. Under the DFE estimation, innovation (+) and innovation (-) are statistically significant in both the short and long term. Financial development (+) and financial development (-) are statistically significant in the long run for the PMG estimator. Except in the short run of the PMG estimator for financial development, Wald tests fail to reject the presence of asymmetric relationships in both the short and long runs of the estimators. Our robustness checks have corroborated our findings under symmetric panel ARDL estimations in Tables 5 and 6.

Table 9: Asymmetric Panel ARDL Estimates

	Estimator	MG	PMG	DFE
	Variable	**Coefficient**	**Coefficient**	**Coefficient**
Long Run	Innovation (+)	0.642	0.059	0.381***
		(0.624)	(0.100)	(0.120)
	Innovation (-)	0.600	0.057	0.392***
		(0.623)	(0.101)	(0.121)
	Fin. Devt. (+)	-0.236	-1.154***	-0.256
		(0.663)	(0.338)	(0.280)
	Fin. Devt. (-)	-0.235	-1.183***	-0.223
		(0.685)	(0.338)	(0.284)
	Trade Open	0.509	1.0697***	0.344*
		(0.381)	(0.177)	(0.191)
	Gross Capital	1.239*	0.909***	-.1579743
		(0.634)	(0.130)	(0.265)
Inn-Asym (Wld)		0.58[0.448]	0.01[0.930]	0.15[0.694]
FD-Asym (Wld)		0.00[0.973]	1.20[0.273]	1.41[0.236]
	Error Correction Term	-0.410***	-0.155***	-0.200***
		(0.096)	(0.024)	(0.024)
	Innovation (+)	0.242	-0.045	0.130**
		(0.190)	(0.110)	(0.067)
	Innovation (-)	0.252	-0.026	0.134**
		(0.191)	(0.107)	(0.069)
	Fin. Devt. (+)	-0.0001	-0.296	-0.103
		(0.391)	(0.258)	(0.084)
	Fin. Devt. (-)	-0.009	-0.305	-0.101
		(0.399)	(0.260)	(0.086)
	Trade Open	0.031	-0.057	0.081
		(0.225)	(0.136)	(0.061)
	Gross Capital	0.208	0.203*	0.013
		(0.242)	(0.111)	(0.062)
	Cons	-0.028	0.486***	1.075***
		(1.171)	(0.073)	(0.276)
CD		6.56[0.000]	51.86[0.000]	31.21[0.000]
AR		11.70***	129.64***	20.80***
Residual		I(0)	I(0)	I(0)
Inn-Asym (Wld)		0.63[0.427]	0.33[0.563]	0.76[0.384]
FD-Asym (Wld)		0.89[0.345]	5.96[0.015]	0.24[0.622]
Observations		510	510	510

Note: Values in ( ) are standard errors. ***, **, * show 1%, 5% and 10% significance levels, respectively.

Source: Authors' computation using Stata 17.0

4.9. Robustness Check: Dynamic Panel Model Two-Step System GMM

As a further test on the robustness of our results, we estimated the dynamic panel model (two-step system generalised method of the moment). Table 10 shows the estimated results of the two-step system GMM model. In applying this model, we proceed as follows: we first run pooled OLS, fixed effect, and random effect models. Based on the Hausman test as shown in Table A1 and Table A2 (Breusch and Pagan Lagrangian multiplier test) in the Appendix, we choose the fixed effect model as both tests are significant at the 1% level. Then we test heteroscedasticity in the fixed effect model through the modified Wald test as described in the Appendix (Table A3). The significance of the Wald test indicates the presence of heteroscedasticity. We remove the heteroscedasticity by using robust standard errors. We then apply the Durbin–Wu test as reported in the Appendix (Table A4), with the significant coefficient indicating the presence of endogeneity. Thus, we move towards GMM models. To choose between difference and system GMM, we apply pooled OLS (see Appendix Table A5a), the fixed effect model (Table A5b), and the difference GMM (Table A5c). The coefficient of difference GMM is the same as under the fixed effect model, which indicates choosing system GMM rather than difference GMM. Therefore, we apply a two-step system GMM. We then address the problem of instrument proliferation by limiting the number of lags to the order of 2. We next remove the problem of autocorrelation by adding another lag of economic growth in the model. Table 10 shows our final two-step GMM model, which is robust to standard error and free from autocorrelation and instrument proliferation. It shows that economic growth in the previous period significantly and positively influences the current period's economic growth. Moreover, financial development significantly and negatively affects economic growth. The findings from the two-step GMM model are in line with our earlier results in Table 6 and Table 7.

Table 10: Dynamic Panel Model: Two-Step System GMM

Economic Growth	Coef.	St.Err.	t-value	Sig
Economic Growth $_{t-1}$	.973	.068	14.33	***
Economic Growth $_{t-2}$	-.042	.063	-0.66	
Innovation	.032	.041	0.79	
Fin. Devt.	-.379	.135	-2.81	***
Trade Open	.069	.085	0.82	
Gross Capital	-.091	.099	-0.92	
Constant	1.759	.536	3.28	***
Mean dependent var	7.087	SD dependent var		1.009
Number of obs	480	Chi-square		99020.343

*** p<.01, ** p<.05, * p<.1

5. DISCUSSION OF RESULTS

The result of innovation, in the long run, is found to be positive and statistically significant at the 1% level. This result provides support for theoretical postulations on the impact of innovation on economic growth (Aghion & Howitt, 1992; Romer, 1986; Cass, 1965; Solow, 1956). Similarly, the finding is in line with previous empirical studies on innovation and economic growth (Jian, et al., 2021; Maradana et al., 2017; Sesay et al., 2018; Pradhan et al., 2018; Pradhan et al., 2020; Sarangi et al., 2022; Wang et al., 2022). These studies documented that innovation incentivises economic growth, and achieving economic growth leads to higher productivity. Further, our results support the hypothesis that innovation enhances economic growth through productivity improvement.

The result of the study also shows that financial development has a positive and significant effect on economic growth in the long run at the 1% significant level. This signifies that higher financial services are linked with greater output growth. Recent financial development through innovation, such as the use of technology in providing banking and other financial services, has greatly promoted financial inclusion, which in turn stimulates the growth and development of SSA. Inventions such as automatic teller machines (ATMs), electronic payment platforms, and internet banking, among others, have considerably enhanced the running of financial systems in SSA during the last two decades. Apart from the provision of financial services, an additional argument that financial development stimulates output growth is its ability to boost the funds available for investment in risky and demanding areas that have a direct link with the growth of output. These findings are in line with previous empirical studies (for example Abeka et al., 2021; Nguyen et al., 2022; Sarwar et al., 2020; Olorogun et al., 2020). In this regard, our result supports the hypothesis that financial development spurs economic growth. Hence, efficient and developed financial systems enhance economic growth and at the same streamline countercyclical investments, which neutralise the severity of economic fluctuations (Aghion et al., 2018).

However, the short-run effect of innovation, in contrast to the long-run impact, was found to be insignificant, implying that innovative activities take a longer time to materialise and create output. This finding is in line with a study by Gyedu et al. (2021) that found that R&D efforts, patents, and trademarks (as proxies of innovation) are negatively significant in G7 countries. In addition, the financial sector in SSA is still subject to high levels of shocks and government intervention, indicating a tendency to have a weak connection with growth of output – especially in the short run.

The outcomes concerning the impacts of the control variables included in the model are in line with our expectations. For instance, the trade openness result was found to be positive and statistically significant at the 10% level. The findings are in line with those of previous studies on trade openness and economic growth (Kumari et al., 2021; Raghutla, 2020). Trade openness is well thought of in some research as a basis for additional exposure to innovation through the transfer of technology. There is, in addition, the recognition that the shifting structure of trading and other cross-border activities in the region with China and other developed and emerging countries has caused expansion in technology transfer which is critical in improving innovation and financial development. Trade openness may also contribute to economic growth by facilitating access to products and services, increasing resource allocation efficiency, and increasing total factor productivity through the diffusion of technology and knowledge. Thus, promoting trade with a greater financial complexity may facilitate businesses to more easily obtain financial resources to sustain innovative activities (Hanley, et al., 2011). Another important explanatory variable included in the model is capital stock – comprising physical and human capital. The findings provide evidence of a positive effect of capital stock on economic growth – supporting the empirical evidence and theories within the economic growth literature (Jibir & Abdu, 2018; Romer, 1986; Cass, 1965; Solow, 1956). Similarly, the findings from the robustness check using the two-step GMM model are in line with our earlier results.

6. CONCLUSION AND POLICY IMPLICATION

This study employed symmetric panel ARDL, common correlated effect ARDL, and asymmetric panel ARDL to investigate the association between innovation, financial development, and economic growth using data for 30 developing countries from SSA. This study is timely given that an overhaul of the financial system and innovative approach to business models has lately been acknowledged and emphasised by the policy makers in SSA as part of their efforts to achieve goals 8 and 9 of the United Nations Sustainable Development Goals (SDGs).

The findings of the paper reveal among other things that innovation and financial development have a positive and significant long-run effect on the economic growth of sub-Sahara Africa. Our findings offer reliable results consistent with several theoretical likelihoods and fresh empirical evidence in the region and beyond. This implies that the long-run growth of the SSA economies is fundamentally connected with the quality of innovation and financial development. In addition, long-term economic growth also depends on creating and maintaining an environment that fosters innovation and financial inclusion and provides incentives for the use of new technology. This means that the application of newly invented inputs and technology and utilisation of modern financial services would promote growth and development. The findings provide new facts concerning how SSA nations can sustain their economic growth through devising approaches supporting financial development and quality innovation.

However, in the short run, financial development and innovation are found to be statistically insignificant in promoting the economic growth of the region. This means that new technologies in the financial sector and new inventions are not being adopted in the short run at the rate needed to support growth and development. It takes time before conceived ideas can be translated into a

meaningful invention that can support output growth. The result suggests that firming up the financial system through satisfactory economic policies may promote the region's financial inclusion in the long term and, in the end, stimulate economic growth. Thus, economic policies geared toward strengthening the region's financial sector may expand its innovative capacity as well, which in turn stimulates output growth.
Our findings of a positive and significant impact of innovation and financial development together with capital stock and trade openness suggest that these variables favourably determine the output growth of the region. These findings support modern endogenous growth theories that emphasise the role of financial development, innovation, and capital stock in growth and development.

The study recommends that policy makers in the region must work in close collaboration with stakeholders in financial institutions and business enterprises in enhancing innovative activities through supporting inventions and scientific discoveries. The financial system forms a central factor in the growth of output. In this regard, governments in the region need to unceasingly expand the allocative efficiency of the financial system, which stimulates regional development. There is also a need for policy makers in the region to enact relevant policies to ensure rigorous regulation and supervision of the financial sector to deliver stability, which will pave the way for achieving the financial inclusion agenda of the sustainable development goals (SDGs) in the region.

Governments in the region can equally play a significant part in creating a legislative framework supporting the advancement of innovation financing through strengthening patent protection across the region. Similarly, there is a need to synchronise the innovative activities in the region by ensuring a strong linkage between research institutes, industries, and tertiary education centres in promoting innovative activities**.** Similarly, governments in the region need to design a well-functioning technological infrastructure by working together through interactive and synergistic approaches with the private sector and other stakeholders as such a well-equipped technological infrastructure remains a strategic cornerstone in upholding regional innovation and financial development.

This study provides robust findings through the use of numerous econometric techniques and a large number of countries from the region, allowing an adequate generalisation of the results to be made for the purpose of policy prescription. However, one area that requires further exploration by future researchers is the use of more than one measure of innovation and financial development in analysing the relation between the variables and economic growth.

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APPENDIX

Table A1: Hausman test to choose between REM and FEM

	Coef.
Chi-square test value	39.072
p-value	0

Table A2: Breusch and Pagan Lagrangian multiplier test for random effects

	Coef.
chibar2(01)	3637.63
Prob > chibar2	0.0000

Table A3: Modified Wald test for group wise heteroscedasticity in fixed effect regression model

	Coef.
chi2 (30)	959.54
Prob>chi2	0.0000

Table A4: Tests of endogeneity

	Coef.
Durbin (score) chi2(1)	8.31309 (p= 0.0039)
Wu-Hausman F(1,444)	8.35662 (p = 0.0040)

Compare the co-efficient of Lagged DVs to choose between System and Difference GMM (Table A5a, Table A5b, and Table A5c)

Table A5a: Pooled OLS

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.981	.007	143.51	0	.968	.995	***
Innovation	-.001	.004	-0.13	.896	-.009	.008	
Fin. Devt.	-.031	.022	-1.38	.168	-.074	.013	
To	.032	.012	2.64	.009	.008	.056	***
Gross Capital	-.06	.032	-1.91	.056	-.122	.002	*
Constant	.383	.141	2.72	.007	.106	.66	***

Mean dependent var	7.045	SD dependent var	1.020
R-squared	0.981	Number of obs	510
F-test	5558.438	Prob > F	0.000
Akaike crit. (AIC)	-555.921	Bayesian crit. (BIC)	-530.515

**** p<.01, ** p<.05, * p<.1*

Table A5b: FE model

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.795	.021	38.31	0	.752	.837	***
Innovation	.086	.029	3.00	.006	.027	.145	***
Fin. Devt.	-.084	.067	-1.25	.223	-.221	.054	
Trade Open	.071	.052	1.38	.179	-.034	.176	
Gross Capital	-.015	.041	-0.36	.719	-.1	.07	
Constant	1.12	.32	3.50	.002	.465	1.774	***

Mean dependent var	7.045	SD dependent var	1.020
R-squared	0.867	Number of obs	510
F-test	407.764	Prob > F	0.000
Akaike crit. (AIC)	-664.430	Bayesian crit. (BIC)	-643.258

**** p<.01, ** p<.05, * p<.1*

Table A5c: Diff-GMM

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Economic Growth $_{t-1}$	.795	.039	20.44	0	.715	.874	***
Innovation	.077	.044	1.75	.091	-.013	.167	*
Fin. Devt.	-.094	.073	-1.29	.205	-.242	.054	
Trade Open	.203	.122	1.67	.105	-.045	.452	
Gross Capital	.116	.153	0.76	.452	-.195	.428	

Mean dependent var	7.087	SD dependent var	1.009
Number of obs	480	F-test	.

**** p<.01, ** p<.05, * p<.1*