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Article

Inclusive Finance, Banking Sector Development, and Economic Development: the Moderating Role of Digital Finance

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Abstract

Purpose: This paper investigates the moderation role of digital finance in the relationship among inclusive finance, banking sector development, and economic development in Africa. **Design/Methodology/Approach:** We construct indices through the Principal Component Analysis to measure inclusive finance, digital finance, and banking sector development in a panel of 39 selected African countries over the period, 2004-2022. Subsequently, we employ the two stage system Generalized Method of Moments estimator to examine the moderating effect of digital finance on the key variables. **Findings:** The results showed persistence of economic development with its lag recording positive and statistically significant relationship with the dependent variable. This result suggests that earlier levels of economic development serves as positive and significant drivers of the current levels of economic development. The results also indicate that digital finance can spike economic development in the presence of inclusive finance and banking sector development. We document evidence of negative impact of increasing population growth on economic development. **Originality:** This paper provides the first empirical evidence of the moderating role of digital finance on the effect of inclusive finance and banking sector development on economic development from the African perspective. **Practical Implication:** The promotion of digital finance applications will improve inclusion and banking development which will enhance economic development, while inclusion policy should be able to address the bottlenecks such as inadequate digital infrastructure. **Social Implication:** Greater access to finance through digital finance can promote banking sector development which can substantially support poverty alleviation and long-term development resulting into economic development.

Keywords: inclusive finance; digital finance; economic development; banking sector development; moderation role; Africa; generalized method of moments (GMM); principal component analysis; technology acceptance model; human development index

1. Introduction

There is a growing concern for the need for developing countries to pursue policies that will bring about higher levels of economic development than mere achievement of economic growth. Economic development focuses on the standard of living, better education, poverty eradication, a cleaner environment, more equality of opportunity, greater individual freedom, as well as increased employment opportunities of a country. UNDP (2002) emphasized that developing countries must pursue sustained growth to reduce poverty and achieve long-term development goals (Ele and Ogbonna, 2023). While several African countries have recorded relatively high growth rates over the past two decades, this has not been accompanied by corresponding levels of economic development, especially when compared to East Asian countries, where growth has been strongly linked to poverty reduction and human development.

Within this context, inclusive finance has emerged as a crucial driver of economic development. Literature suggests that inclusive finance expands opportunities for all, particularly the poor and unbanked, by enabling access to financial services and resources that enhance capital accumulation (Ozili, 2018; World Bank, 2018). Access to affordable credit, savings, insurance, and transaction accounts fosters entrepreneurship, reduces poverty, and promotes broader economic participation (Hasan Amana et al., 2024). According to Peachey and Roe (2004), inclusive finance enhances economic development through three channels: efficient resource allocation, mobilization of savings, and risk mitigation. Despite these benefits, empirical evidence on the impact of inclusive finance on economic growth and development is mixed. While some studies highlight its positive effects (Boachie and Adu-Darko, 2024; Dahiya and Kumar, 2020), others find negative or inverse relationships, often due to inefficiencies or excessive financial inclusion (Chiwira et al., 2021; Menyelim et al., 2021; Sharma, 2016; Thathsarani et al., 2021).

One of the most significant enablers of inclusive finance is digital finance, which leverages technology to provide affordable, efficient, and accessible financial services. Digital platforms such as mobile banking, digital payments, and lending apps expand financial inclusion by lowering transaction costs and increasing outreach (Ozili, 2018). By enabling access to payments, savings, and credit without physical banking infrastructure, digital finance facilitates consumption smoothing, savings mobilization, and investment growth. However, studies on the relationship between digital finance and economic development remain inconclusive. Some document positive effects (Chinoda and Kapingura, 2023; Daud and Ahmad, 2023), while others highlight risks of instability and negative outcomes (Antwi and Kong, 2023).

Banking sector development also plays a vital role in economic transformation. A stable and efficient financial system ensures efficient resource allocation, risk management, and macroeconomic stability, which in turn promotes employment and sustained development (World Bank, 2020). Yet, empirical findings are equally mixed. For example, Cheng et al. (2021) report that financial development can hinder growth in high-income countries, while Wesiah and Onyekwere (2021) find a bidirectional causal link between banking sector development and economic growth in the UK. These findings suggest that the banking sector's impact on development is context-specific, depending on institutional quality, technological adoption, and economic structure.

Against this backdrop, the interconnection among inclusive finance, banking sector development, and digital finance has become increasingly important, particularly in Africa. Digital finance has transformed the inclusiveness of financial systems by making financial services more convenient, affordable, and accessible, thereby strengthening the role of inclusive finance and banking sector development in promoting growth and poverty reduction. Yet, the moderating role of digital finance in this relationship remains underexplored. Key questions arise: How do inclusive finance, banking sector development, and digital finance individually affect economic development in Africa? Does digital finance moderate these relationships, and if so, how?

This study focuses on Africa for three reasons. First, the continent has experienced a surge in digital financial adoption, particularly during and after the COVID-19 pandemic, with the rise of mobile money and lending apps (Fu and Mishra, 2022). Second, financial inclusion remains low compared to other regions: only 49% of adults in Sub-Saharan Africa have an account, compared to 76% globally (Demirguc-Kunt et al., 2022; World Bank, 2022). Third, although African banking systems have undergone reforms, they remain underdeveloped due to weak institutional quality, which constrains their contribution to economic development (David et al., 2014; Krause, 2016). Thus, understanding the moderating role of digital finance in the nexus among inclusive finance, banking sector development and economic development is crucial for promoting inclusive and sustainable growth across Africa.

This study contributes to literature in diverse ways. First, the literature dealing with the direct link between digital finance, inclusive finance, banking sector development and economic development is still embryonic. Most importantly, to our best of knowledge no study has looked at the moderating role of digital finance among the nexus of the trio. Thus, this study will provide a

new theoretical framework that integrates digital finance into the models of economic development thereby providing more understanding of how this relationship is affected by technology. Second, instead of relying on single-variable base measures, we constructed and used composite indices for these variables. These indices provide comprehensive information about the variables. Moreover, this study contributes to policy consideration where policy must leverage digital finance for inclusive economic growth and development. The results show that digital finance and inclusive finance independently have a significant impact on economic development in Africa, and there is a significant combined effect of inclusive finance, banking sector development, and digital finance on economic development, irrespective of the measure used. This suggests that digital finance has a significant moderating effect on the inclusive finance, domestic banking sector development-economic development nexus.

We outline the remaining part of the study as follows: the literature review is covered in section 2, section 3 contains the methodology, results, and discussions are in section 4 while section 5 presents our conclusion, policy recommendations, and future research directions.

2. Literature Review

Various theories come into play regarding this current study. There is the need for proper understanding of how these theoretical components interplay to influence economic outcomes.

2.1. Theoretical Review

Inclusive finance plays a crucial role in economic development, especially in the areas of poverty reduction and inequality. First, Public Good Theory by Samuelson (1954; 1955) stipulates that financial services should be seen as public goods since they are 'non-excludable and non-rival' and should be accessible to all. Second, the Vulnerable Group Theory by Ozili (2024) explains that inclusive finance policies should be able to address structural barriers that perpetuate poverty and inequality so that the vulnerable groups and communities are able to have access to financial services. By so doing, social equity and economic empowerment will be achieved and will help the poor transition to more productive and market-oriented enterprises.

The banking sector plays a pivotal role in economic transformation because it provides the needed infrastructure that mobilizes and allocates resources efficiently to the productive sectors of the economy. Similarly, McKinnon-Shaw Hypothesis (1973) opined that the removal of interest rate caps and credit rationing liberalises the financial system, which encourages savings and investment, thereby positively impacting the global economy. The Diffusion of Innovations Theory (Rogers, 1962) and the Technology Acceptance Model (Davis, 1989) explain how digital finance rapidly expands access to financial services, particularly in underserved regions. Again, the Unified Theory of Acceptance and Use of Technology by Venkatesh *et al.* (2003) explains how the adoption of digital financial tools, such as mobile banking and FinTech applications creates affordable transaction costs which help remove the geographical barriers. In line with the New Growth Theory by Romer (1986), digital finance is able to create a platform for innovation that expands economic opportunities for diverse groups of people. The synergy of these theories contributes to inclusivity, poverty alleviation, increased productivity, and higher living standards through the creation of a virtuous cycle that drives economic development.

2.2. Empirical Studies

The role of inclusive finance in poverty alleviation cannot be overstated. Individuals are able to manage their finances, invest in education or business enterprise and are able to save towards eventualities if they gain access to financial services. This can lead to improved living standards and reduced inequality (Hasan *et al.*, 2024). Research indicates that financial inclusion is positively correlated with poverty reduction efforts (see Yakubi *et al.*, 2022). Employing Generalized Method of Moments (GMM) system on panel data from 22 SSA nations from 2012 to 2018, Ifediora *et al.* (2022)

examined the effect of inclusive finance on economic development. The findings indicate that the availability, penetration, and composite dimensions of inclusive finance significantly and positively impact economic development. Makina and Walle (2019) examine the impact of inclusive finance on economic development in 42 African countries over the period, 2004-2014 by relying on the system GMM dynamic panel data estimator. The results intimate that economic growth and development is significantly and favourably influenced by inclusive finance which is in tandem with that of Adedokun and Ağa (2021) in the same African context. Other empirics with similar findings include Dahiya and Kumar, 2020 and Shen *et al.*, 2021. Studies outside the soil of Africa produced similar findings (e.g., Abdul Karim *et al.*, 2022; Ahmad *et al.*, 2021).

Some studies have considered the effect of digital finance on economic growth and development. According to Zhang *et al.* (2022), digital finance is able to promote economic growth through the alleviation of financing constraints. Moreover, it has the ability to solve the problem of unbalanced and inadequate regional development by providing financial services for 'long-tail' population (Lee *et al.*, 2022); digital financial inclusion positively impacts economic growth and development (Iddrisu and Chen, 2022; Thaddeus *et al.*, 2020; Ugwuanyi *et al.*, 2022) and has a positive influence on the level of women's participation in the labour markets in Africa (Elouardighi and Oubejja, 2023).

There are conflicting results from the studies that looked at the impact of banking sector development on economic growth and development. One group of scholars argued that a well-functioning financial system supports the growth of the economy which eventually promotes economic development (e.g., Goldsmith, 1959; Wu *et al.*, 2020). For example, Guru and Yadav (2019) find a positive and significant relationship between financial development and the expansion of some economies of BRICS over the period, 1993-2019 suggesting that financial development was the primary factor of economic growth in the BRICS. Conversely, other studies downplay the impact of financial sector development in stimulating economic growth and development (e.g., Levine, 1997; Meier and Seers, 1984). Others argued that after a certain threshold, financial development has a weakening effect on growth and found that credit booms increase the promulgation and amplification of shocks that harm innovation-driven sectors (e.g., Swamy and Dharani, 2019) and too much finance has a diminishing effect on economic growth (Cecchetti and Kharroubi, 2012). The other strand of literature (demand-leading hypothesis) contends that the financial sector couldn't exist if there wasn't an actual economic sector that needed specific forms of financial goods and services. For instance (e.g., Bist, 2018) with others being indifferent about the causal relationship (see Nguyen *et al.*, 2022; Opoku *et al.*, 2019).

Other studies looked at the relationship among digital finance, inclusive finance and economic growth. For instance, Daud and Trinugroho (2024) examine the relationship between financial inclusion, digital technology and economic growth by employing a dynamic panel data analysis covering 84 countries. The results indicate that both financial inclusion and digital technology independently have positive and significant effects on the countries' economic growth. These results were supported by the findings of the studies by Ahmad *et al.* (2020) and Alhassan *et al.* (2021) in SSA. Others considered institutional quality, financial inclusion and economic growth (e.g., Chinoda and Kapingura, 2024; Gyamfi *et al.*, 2022). These studies indicate the need for effective institutions to help promote the impact of financial development on economic development.

It is evidently clear from the above that less is known regarding studies on the trio. Again, the role of digital finance may go a long way to moderating the relationship among inclusive finance, banking sector development and economic development in Africa. This gives the reason for us to undertake this particular study. To achieve the objectives of this study, we proposed the theoretical framework and respective hypotheses as follows:

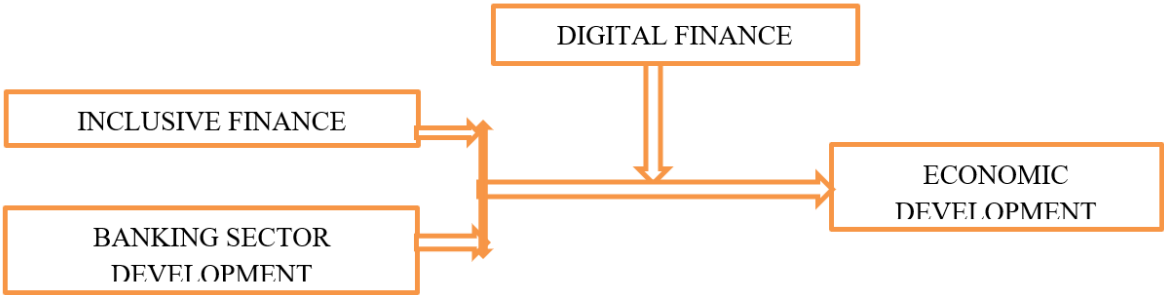


Figure 1. Theoretical framework and Hypotheses.

- H1. Both Inclusive finance and Banking sector development can promote economic development in Africa.
- H2. Digital finance can serve as a moderating factor in the inclusive finance, banking sector development and economic development nexus.

3. Materials and Methods

3.1. Model Specification and Estimation Strategy

Several estimation techniques are associated with growth literature. Based on our panel dataset, objectives and empirics, the two-step system GMM was the preferred method of estimation for our dynamic models. The GMM estimators come in various forms. The brains behind these estimators were Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998) and Holtz-Eakin, Newey, and Rosen (1988). Two main types of estimators within the GMM mostly used in literature are the system GMM and difference GMM. Literature suggests the superiority of the system GMM over difference GMM (see Agbloyor *et al.*, 2016; Gyamfi *et al.*, 2022). The system GMM is superior to the difference GMM due to some flaws exhibited by the latter. First, “it uses the lagged levels of the explanatory variables as instruments for the regression equation in differences which has been found to be inappropriate” (cited in Gyamfi *et al.*, 2022). Second, “it nullifies the country-specific effect in the estimation” (cited in Gyamfi *et al.*, 2022). Conversely, the two –step system GMM is able to surmount these problems and “it has been argued that it produces more asymptotic efficient estimates than one-step system GMM estimator, particularly in the presence of heteroskedasticity” (see Aluko *et al.*, 2018) and handles endogeneity issues associated with the explanatory variables. The validity of the instrument is tested by the Hansen test (over-identification restrictions) and the Sargan test (1958).

Following theoretical and empirics, we included some control variables to account for cross-country differences in our key variables of interest. Therefore, financial liberation theory (McKinnon, 1973; Shaw, 1973), theory of financial innovation (Silber, 1983), diffusion of innovation theory (Rogers, 1995) and technology acceptance model (Davis, 1988) form the basis of our study models. In order to establish the links amongst these key variables and the moderating role of digital finance in those relationships, we specify models 1-7 by following the previous works such as Daud and Trinugroho (2024) and Lam *et al.* (2019).

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2IFI_{it} + \beta_3DFI_{it} + \Omega X_{it} + e_{it}.....1$$

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2IFI_{it} + \beta_3(IFI_{it} \times DFI_{it}) + \beta_4DFI_{it} + \Omega X_{it} + e_{it}.....2$$

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2BSDI_{it} + \beta_3DFI_{it} + \Omega X_{it} + e_{it}.....3$$

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2BSDI_{it} + \beta_3DFI_{it} + \beta_4(BSDI_{it} \times DFI_{it}) + \Omega X_{it} + e_{it}.....4$$

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2IFI_{it} + \beta_3BSDI_{it} + \beta_4DFI_{it} + \Omega X_{it} + e_{it}.....5$$

$$HDI_{it} = \beta_0 + \beta_1HDI_{it-1} + \beta_2IFI_{it} + \beta_3BSDI_{it} + \beta_4DFI_{it} + \beta_5(BSDI_{it} \times DFI_{it}) + \beta_6(IFI_{it} \times DFI_{it}) + \beta_7(IFI_{it} \times BSDI_{it} \times DFI_{it}) + \beta_8POP_{it} + \beta_9EDU_{it} + \beta_{10}INFL_{it} + \beta_{11}BSPRD_{it} + \beta_{12}TRADE_{it} + \beta_{13}INSQ_{it} + e_{it}6$$

Where, *HDI* is economic development measured by human development index, *DFI*, *BSDI* and *IFI* are respectively the indices of digital finance, banking sector development and inclusive finance, *X_{it}* is a vector of control variables (including population growth, Inflation, trade openness, institutional quality, bank interest rate spread), subscript *i* and *t* represent country specific and time, while β_0 - β_6 and Ω are parameters to be estimated respectively.

Following Lam et al. (2019), we took a partial derivative of equation (6) with respect to digital finance to obtain the net effect of digital finance on economic development. This gives equation (7).

$$\frac{\partial HDI_{it}}{\partial DFI_{it}} = \beta_4 + \beta_5BSDI_{it} + \beta_6IFI_{it} + \beta_7IFI_{it} \times BSDI_{it}.....7$$

Where, β_5BSDI_{it} , β_6IFI_{it} , $\beta_7IFI_{it} \times BSDI_{it}$, are the mean values of banking sector development, inclusive finance and the combined mean value of banking sector development, and inclusive finance.

We performed robust checks by replacing the dependent variable with gender development index (GDI) and regress it on the predictors. The accompanying models are specified below:

$$GDI_{it} = \beta_0 + \beta_1GDI_{it-1} + \beta_2IFI_{it} + \beta_3BSDI_{it} + \beta_4DFI_{it} + \Omega X_{it} + e_{it}8$$

$$GDI_{it} = \beta_0 + \beta_1GDI_{it-1} + \beta_2IFI_{it} + \beta_3BSDI_{it} + \beta_4DFI_{it} + \beta_5POP_{it} + \beta_6EDU_{it} + \beta_7INFL_{it} + \beta_8BSPRD_{it} + \beta_9TRADE_{it} + \beta_{10}INSQ_{it} + e_{it}9$$

$$GDI_{it} = \beta_0 + \beta_1GDI_{it-1} + \beta_2IFI_{it} + \beta_3BSDI_{it} + \beta_4DFI_{it} + \beta_5(BSDI_{it} \times DFI_{it}) + \beta_6(IFI_{it} \times DFI_{it}) + \beta_7(IFI_{it} \times BSDI_{it} \times DFI_{it}) + \beta_8POP_{it} + \beta_9EDU_{it} + \beta_{10}INFL_{it} + \beta_{11}BSPRD_{it} + \beta_{12}TRADE_{it} + \beta_{13}INSQ_{it} + e_{it}10$$

With reference to Lam et al. (2019), the partial derivative of equation (10) with respect to digital finance yielded equation (11) that gives the net effect of digital finance on economic development.

$$\frac{\partial GDI_{it}}{\partial DFI_{it}} = \beta_4 + \beta_5BSDI_{it} + \beta_6IFI_{it} + \beta_7IFI_{it} \times BSDI_{it}.....11$$

Where, β_5BSDI_{it} , β_6IFI_{it} , and $\beta_7(IFI_{it} \times BSDI_{it})$, are the mean values of banking sector development, inclusive finance, and the combined mean value of banking sector development, and inclusive finance.

To ensure that our dataset is free from the problems of cross sectional dependence (CD), we subjected the dataset to three different CD tests: Pesaran CD Test, Frees Test and Friedman Test. The tests results are shown in Appendix Table A5 under appendices. The results show that the dataset is free from the issues of CD since the tests failed to reject the null hypothesis.

3.2. Data Source and Description of Variables

We employed annual secondary data from 41 African countries over the period, 2004-2022. The inclusion was solely based on the availability of the necessary data. Table 1 presents the data sources and descriptions of all the variables or indicators used for this study. All the banking sector development variables were sourced from the Global Financial Development Database (GFDD, 2022). The digital finance variables were sourced from GFDD, variables for inclusive finance were taken from International Monetary Fund (IMF) while the variables for economic development were taken from the United Nations Development Programme (UNDP), and World Development Indicators (WDI). We picked the data of the control variables from WDI, GFDD and the World Governance Indicator (WGI).

Table 1. Data and Description of Variables.

Variable	Notation	Description/measurement	Source
Economic Development 1	HDI	Human development indicator- the geometric mean of education, health and standard of living	UNDP
Economic Development 2	GDI	Gender development indicator- female HDI scaled over men HDI	UNDP
Banking Development Index	BSDI	PCA output from 14 DBSD variables	
BSD ₁	D ₁	Private credit by deposit money banks to GDP (%)	GFDD
BSD ₂	D ₂	Deposit money banks' assets to GDP (%)	GFDD
BSD ₃	D ₄	Deposit money bank assets to deposit money bank assets and central bank assets (%)	GFDD
BSD ₄	D ₅	Liquid liabilities to GDP (%)	GFDD
BSD ₅	D ₆	Central bank assets to GDP (%)	GFDD
BSD ₆	D ₁₂	Private credit by deposit money banks and other financial institutions to GDP (%)	GFDD
BSD ₇	D ₁₄	Domestic credit to private sector (% of GDP)	GFDD
BSD ₈	E ₁	Bank net interest margin (%)	GFDD
BSD ₉	E ₃	Bank noninterest income to total income (%)	GFDD
BSD ₁₀	E ₄	Bank overhead costs to total assets (%)	GFDD
BSD ₁₁	E ₇	Bank cost to income ratio (%)	GFDD
BSD ₁₂	S ₁	Bank Z-score	GFDD
BSD ₁₃	S ₄	Bank credit to bank deposits (%)	GFDD
BSD ₁₄	S ₆	Liquid assets to deposits and short term funding (%)	GFDD
Inclusive Finance Index	IFI	PCA output from seven inclusive finance variables	
Inclusive Finance ₁	BCBPTA	Borrowers from commercial banks per 1000 adults.	IMF
Inclusive Finance ₂	DCBPTA	Depositors with commercial banks per 1000 adults.	IMF
Inclusive Finance ₃	BBPHTA	Commercial bank branches per 100,000 adult	IMF
Inclusive Finance ₄	BBPTK	Bank branches per 1000 km square,	IMF
Inclusive Finance ₅	BAPTA	Bank account per 1000 adults	IMF
Digital Finance Index	DFI	PCA output from 5 digital finance variables	
Digital Finance ₁	PAYMENT	Made a utility payment: using a mobile phone (% age 15+)	GFDD
Digital Finance ₂	RECEIVEDMONEY	Received domestic remittances: into an account (% age 15+)	GFDD
Digital Finance ₃	MPSPPTA	Mobile phone subscriptions per 100 adults	GFDD
Digital Finance ₄	ATMPHTA	ATMs per 100,000 adults	IMF
Digital Finance ₅	ATMPPTK	ATMs per 1000 km square,	IMF
Interaction term1	IFI*DFI	An interaction between Inclusive finance and digital finance	
Interaction term2	BSDI*DFI	An interaction between banking sector development and digital finance	

Interaction term3	IFI*BSDI**DFI	An interaction among inclusive finance, banking sector development, and digital finance,	
Trade openness	TRADE	Sum of export and import scaled over GDP	WDI
Trade2	EGDPR	Export to GDP ratio	
Trade3	IGDPR	Import to GDP ratio	
Institutional quality	INS QUAL	An average of the six institutional quality variables: control of corruption, voice and accountability, political stability and “absence of violence/terrorism”, rule of law, regulatory quality, and government effectiveness	
Education	EDU	Secondary school enrolment	WDI
Population Growth	Pop	Population growth rate (% annual)	WDI
Bank Spread	BSPRD	Bank lending- deposit rates	GFDD
Economic growth	GDP	GDP growth (annual %)	WDI
Inflation	INFL	Consumer prices (annual %)	WDI

Notes: WGI is World Governance Indicator; GFDD is Global Financial Development; WDI is World Development Indicators; IMF is International Monetary Fund.

Economic Development is the dependent variable. Studies on economic growth or development mostly used either annual GDP growth rate (e.g., Banna and Alan, 2020:2021; Aluko and Ajayi, 2018) or GDP per capita (Pradham *et al.*, 2017: 2019). We rather used two indices (human development index (HDI) and gender development index (GDI). HDI gives holistic assessment and highlights the discrepancies in human development outcomes within economies with similar levels of incomes. HDI usually focus on three key dimensions: education, health and standard of living. It assesses the overall development of a country as it measures both qualitative and quantitative aspects of growth unlike GDP that is solely quantitative in nature. The education aspects of HDI measures mean years of schooling for adults aged 25 and others such as expected years of schooling for children entering school. The health aspect measures life expectancy at birth, while gross national income (GNI) per capita adjusted for purchasing power parity measures the standard of living aspect of economic development. The geometric mean of these three dimensions (normalised indices) represents a country’s overall economic development with scores ranges from zero (0) (no development) to one (1) (full development).

Our second measure of economic development, GDI highlights possible gender inequalities regarding economic development, and through that certain interventions could be implemented by policymakers to promote equality in economic opportunities that enhance economic development in the countries. GDI was introduced alongside the Gender Empowerment Measure (GEM) in 1995. It provides information about the disparities between men and women in the key dimensions of economic development such as education, health and economic resources. It is measured by scaling female HDI over men HDI with three levels of interpretations. A value above one (1) suggests better outcomes for women, value below one is an indication that men enjoy more economic development than women, and a value close to one suggest equal opportunities for both gender.

Banking Sector Development (BSD): We used 14 variables or indicators from the three dimensions of financial sectors: depth, stability and efficiency in constructing the BSD index (BSDI)by employing the Principal Component Analysis (henceforth PCA). PCA helps to transform a number of correlated variables into a smaller number of uncorrelated variables and “reduces a set of observed variables into principal components which as much as possible retain information from the original set of variables” (Aluko *et al.*, 2018). This variable is expected to have positive impact on economic development (Guru and Yadav, 2019; Wu et al., 2020). Similarly, through PCA approach we used five digital finance proxies to construct the digital finance index (DFI). These variables or indicators are indicated in table 1. We expect this variable to have positive influence on economic development. On the other hand, seven proxies from the supply and demand dimensions of inclusive finance were

used to construct the inclusive finance index. This approach is in tandem with previous studies (see Anarfo *et al.*, 2020; Iddrisu *et al.*, 2022). We expect inclusive finance to have positive and significant influence on economic development as was recorded in previous studies (see Mwakalila and Kasongwa, 2024).

Following literature (see Aluko *et al.*, 2018; Gyamfi *et al.*, 2022; Iddrisu *et al.*, 2022;) we made use of the following control variables (macroeconomic): trade openness, inflation, institutional quality, bank interest rate spread, population growth, and education. Trade Openness: it mirrors the country’s overall trade activity. The level to which a country is opened to external trade depicts its trade openness. This variable is measured by scaling the sum of imports and exports over GDP, with a higher ratio suggesting a higher level of integration and vice versa. We also included Export-to-GDP ratio and Import-to-GDP ratio to verify whether exports or imports affect economic development differently. Inflation is the variations in the general prices of goods and services. This variable is proxy by the annual consumer price index (%). We expect negative relationship between economic development and increasing levels of inflation (see Gyamfi *et al.*, 2022).

Institutional quality reflects the quality of governance which normally serves as proxy for economic institutions (see Aluko *et al.*, 2018). Obviously, its impact on BSD, IF, and overall economic development is paramount (Nanivazo *et al.*, 2021; Rojas-Suárez, 2016). Following previous users (see Iddrisu *et al.*, 2022; Kaufmann *et al.*, 2009) we use the average of the six recommended governance indicators (see table1). We expect positive connection between this variable and economic development. We proxy population by the annual population growth rates (%). Higher population growth impedes inclusive finance hence, we expect a negative relationship between this variable and economic development. Education was proxy by secondary school and it is expected that an individual’s level of education affects his/her inclusivity and the overall economic development (see Allen *et al.*, 2016).

3.3. Principal Component Analysis (PCA)

The indices help solve the possible issues of multicollinearity and over-parameterization as a single measure of DF or BSD or IF (Ahamed and Mallick, 2019). This estimation technique stipulates that the *j*th factor can be written as:

$$\begin{aligned} BSDIX_j &= W_{j1}X_1 + W_{j2}X_2 + W_{j3}X_3 + \cdots \\ &+ W_{jp}X_p \dots\dots\dots 12a \\ IFIX_j &= W_{j1}X_1 + W_{j2}X_2 + W_{j3}X_3 + \cdots \\ &+ W_{jp}X_p \dots\dots\dots 12b \\ DFIX_j &= W_{j1}X_1 + W_{j2}X_2 + W_{j3}X_3 + \cdots \\ &+ W_{jp}X_p \dots\dots\dots 12c \end{aligned}$$

Where,
BSDIX_j, IFIX_j and DFIX_j are banking sector development, inclusive finance, and digital finance indices respectively, the factor score weights are represented by W_j; the respective components are indicated by X and P denotes the number of variables in the equation. Our composite indices have the components or indicators picked from the key dimensions of the respective measures. Our indices are specified as follows:

$$DBSDIX = f(D_1, D_2, D_3, D_4, D_5, D_6, D_7, E_1, E_2, E_3, E_4, S_1, S_2, S_3) \dots\dots\dots 13a$$

$$IFIX = f(BCBPTA, DCBPTA, ATMPHTA, BBPHTA, BBPTK, ATMPTK,, BAPTA) \dots\dots\dots 13b$$

$$DFIX = f(PAYMENT, RECEIVEDMONEY, MBIB-DP, MMIBTRANSACTION) \dots\dots\dots 13c$$

Appendix Figure A.1 - A.3 (under appendices) show the scree plots from the principal component analyses. These figures are under the Supplementary File. The results of the eigenvalues, principal components (Appendix Tables A.2 - A.4) and the Kaiser-Meyer-Olkin (KMO-1974) measures of sampling adequacy values indicate the adequacy of our variables for the construction of the respective indices (DFI, IFI and BSDI) by employing the orthogonal vari-max rotation coefficients scoring method.

4. Results and Discussions

Notice here that we carried out outlier checks on the dataset before other analysis were made. Variables having outlier issues were corrected thoroughly through a winsorization process. Thus, summary statistics, correlation matrix and regression results are all free from problems of outliers.

4.1. Descriptive Statistics

Table 2 shows the dynamism of our dataset. The conclusion of this study will largely depends on the understanding and insight of the nature of the data we have used. Since the issues of outliers have been dealt with before the main analysis, our final dataset shows no abnormal pattern that will warrant any special treatment. Our descriptive statistics suggests that a number of the variables are not normally distributed since some values of skewness and kurtosis of some variables fall outside the 0 and 3 limits respectively. However, GMM is robust to non-normality hence, we envisage no problem. Moreover, the correlation matrix suggests no issues of multicollinearity. Table 3 presents the correlation matrix of the variables we employed in the study. The dependent variable (HDI) has a mean value of 0.5338, suggesting an average economic development in the selected countries for the study period. The alternative measure of economic development (GDI) has a mean value of 0.8678. This suggests that on average, equal opportunities exist for both genders in the selected countries. Moreover, in some of the countries there exist opportunity disparities favouring the males over the females and vice versa. Also, the results show that there exist lower levels of development of inclusive finance, digital finance and the banking sector in the study jurisdiction over the study period.

Table 2. Descriptive Statistics.

Var.	Obs.	Mean	Std. Dev.	Min.	Max.	Skewness	Kurtosis
HDI	741	0.5338	0.1133	0.286 0	0.8230	0.4717	2.4942
GDI	741	0.8678	0.0916	0.5956	1.0170	-1.4705	5.4183
IFI	702	0.0020	0.1793	-0.4395	1.0483	1.3229	8.8833
BSDI	741	-0.0142	0.4858	-0.8427	1.0830	0.8658	2.8218
DFI	702	0.0137	0.1140	-0.8752	0.7018	0.2435	12.4812
EDU	702	0.0089	0.0817	-0.8531	0.9938	1.4741	6.1968
INSQUAL	702	0.0004	0.0727	-0.4236	0.4317	-0.0458	7.3190
INFL	741	7.2075	6.2319	-8.9747	22.9535	0. 9596	3.4104
POP	741	2.4977	0.7382	0.9691	4.4360	-0.4504	2.6760
EGDPR	741	29.1956	14.1736	-11.0047	58.7573	0.3899	2.6192
IGDPR	741	35.3962	13.3125	1.5712	64.4188	0.4864	2.8438
BSPREAD	585	0.1741	8.1699	-61.0554	56.4603	-0.2182	18.8429
TRADE	702	0.2761	9.1050	-47.7432	53.3083	-0.0344	8.6463

Note: HDI and GDI are economic development, IFI, BSDI &DFI are the indices of inclusive finance, banking sector development and digital finance respectively, EDU is education, INSQUAL is institutional quality, INFL is inflation, POP is population, EGDPR is export to GDP ratio, IGDPR is import to GDP ratio, BSPREAD is bank interest rate spread and Trade is total trade to GDP.

Table 3. Correlation Matrix.

	HDI	GDI	IFI	BSDI	DFI	EDU	INSQ	INFL	POP	EGDP	IGDP	BSPD	TRAD
HDI	1.00												
GDI	0.50*	1.00											
IFI	0.02	0.13*	1.00										
BSDI	0.49*	0.08*	-0.09*	1.00									
DFI	0.13*	0.13*	0.68*	0.01	1.00								
EDU	-0.18*	-0.08*	0.08*	-0.11*	-0.05	1.00							

INSQ	-0.06	-0.08*	-0.01	-0.03	0.01	-0.07	1.00						
INFL	-0.09*	-0.12*	-0.03	0.064	-0.01	-0.03	-0.00	1.00					
POP	-0.66*	-0.39*	0.04	-0.57*	-0.06	0.09*	0.03	0.06	1.00				
EGDP	0.43*	0.03	-0.09*	0.19*	0.05	-0.08*	-0.05	-0.18*	-0.18*	1.00			
IGDP	0.13*	0.02	-0.08*	0.23*	0.04	0.06	-0.04	-0.12*	-0.24*	0.58*	1.00		
BSPD	0.03	0.02	-0.01	0.02	-0.02	-0.00	-0.05	-0.00	-0.02	0.02	0.02	1.00	
TRADE	-0.03	-0.01	-0.03	0.06	0.00	0.02	-0.00	0.07	-0.03	0.15*	0.17*	0.06	1.00

4.2. Unit Roots Test Results

In order to select appropriate model for the computation of the parameters there is the need check whether the variables are stationary especial in panel data analysis. In that regard, we subjected all the variables for this study to four different types of panel unit root tests: Philips–Perron (PP) test, Harris-Tzavalis (HT) test, the Levine–Lin Chu (LLC) test and Im Pesaran and Shin (IPS) test. We adopted this to obtain more analytical results which in our estimation are better than relying on the univariate ones. Moreover, this allows room for “country-level fixed effects” and differences in time for the coefficients through the panels. Also, there is superior level of flexibility in calculating the coefficients under these approaches as compare to ADF since there are availability of different estimations which allows for testing for similar time effects with “a constant and deterministic trends testing for similar time effects” (Anarfo *et al.*, 2019). Appendix Table A.1 (under appendices) shows the outcomes of the panel root tests. The results stipulate mixed integrated of order zero I (0) and order one I (1) of the variables. Following literature, we took first difference of all the variables of order one I(1) to make them stationary before using them for the analysis.

4.3. Regression Results of Digital Finance, Inclusive Finance, Domestic Banking Sector Development and Economic Development

We find economic development (HDI) to persist positively in all three models with its lag recording positive and statistically significant in explaining the dependent variable as shown in Table 5. The dynamism in the models was exhibited by the inclusion of the one-period lagged dependent variable. This result suggests that earlier levels of HDI serves as positive and significant drivers of the current levels of HDI implying that the benefits of an attained HDI are beyond the current year. Subsequently, achieving the next HDI becomes easy due to the level of attainment of the previous year’s HDI. We find positive and significant link between DFI and HDI across the three models. Model1 has export to GDP ratio, moedl2 has trade to GDP and model3 has import to GDP ratio. This was done to verify whether exports or imports affect economic development differently. Digital finance has the potential to influence inclusive finance by providing easier access to financial products or services. This has the tendency to influence HDI positively by ensuring that more people participate in the economy. Our result is in tandem with studies (e.g., Chen and Peng, 2021; Daud and Trinugroho, 2024) but is in contrast with studies such as Antwi and Kozg (2023) and Azmeh and Al-Raeai (2025).

Table 5. Main Effects Regression Results: Two-step System GMM.

Variables	(1)		(2)		(3)	
	Coeff.	P > Z	Coeff.	P > Z	Coeff.	P > Z
LHDI	0.8513	0.0000***	0.9085	0.0000***	0.8682	0.0000***
DFI	0.0626	0.021**	0.0502	0.047**	0.0455	0.049**
IFI	-0.0271	0.049**	-0.0236	0.061*	-0.0178	0.149
BSDI	-0.0190	0.040**	-0.0029	0.654	-0.0059	0.3080
POP	-0.0132	0.009***	-0.0077	0.003***	-0.0113	0.011**
EDU	0.0029	0.7570	0.0106	0.5080	0.0022	0.745
INFL	-0.0002	0.236	-0.000	0.362	-0.0001	0.335

BSPRD	0.0003	0.236	0.000	0.581	-0.0000	0.571
EGDPR	0.0001	0.8080				
IGDPR					0.003	0.278
TRADE			-0.000	0.377		
INSQUAL	-0.0173	0.4630	0.0051	0.377	-0.0110	0.594
Model Diagnostics						
AR(1)	-2.3(0.022)		-2.1(0.034)		-2(0.049)	
AR(2)	0.71(0.477)		-0.2(0.855)		0.2(0.840)	
Instrument	37		37		38	
Groups	39		39		39	
Hansen test	0.289		0.152		0.250	
Sargan	0.000		0.000		0.000	

Source: The Authors. **Note:** “***, ** and * significant at 1%, 5% and 10% level, respectively” **Note:** HDI and GDI are economic development, IFI, BSDI & DFI are the indices of inclusive finance, banking sector development and digital finance respectively, EDU is education, INSQUAL is institutional quality, INFL is inflation, POP is population, EGDPR is export to GDP ratio, IGDPR is import to GDP ratio, BSPREAD is bank interest rate spread and Trade is sum of exports and imports to GDP ratio.

On the other hand, inclusive finance (IFI) has negative and significant relationship with HDI in model1 and model2. This means that higher levels of IFI are related to lower level of economic development or vice versa. The result seems counterintuitive as it is expected that higher levels of IFI are linked with better HDI outcomes particularly in the areas of education and health. The negative relationship suggests that IFI could have immediate costs short – long term effects (e.g., inefficient allocation of resources or debts) that temporarily hinders economic growth and development. Secondly, structural or regional factors such as poor institutional quality as it is in the case of Africa contributes to this outcome. Again, IFI might exit but does not translate into broader economic development due to systematic issues such as corruption, lack of infrastructure and poor functioning of institutions (see Sharma 2016; Thathsaram et al., 2021) and studies with contrasting result (Boahie and Adu-Darko, 2024; Dahiya and Kumar, 2020; Law and Kabir Hassan, 2022).

Additionally, banking sector development is negatively and statistically significant in only model1. The negative relationship indicates that advanced levels of banking sector development (BSDI) are linked with lower levels of HDI. This might be as a result of poor BSDI or instability which can hinder the development efforts by limiting access to necessary financial resources. Thus, inefficiencies in the banking systems (underdeveloped) in Africa leads to misallocation of resources which can hinder economic growth and development. Moreover, high cost of financial services may exclude a section of the population limiting their positive impact on economic growth. Again, weak regulatory frameworks in African countries as poor governance and regulatory oversights can lead to issues such as corruption or financial instability which negatively affect economic development. Other studies that are in line with our finding include (Agyemang-Badu et al., 2018; Chinoda and Kapingura, 2024; Levine, 1997; Lucas Jr, 1988; Meier and Seers, 1984). Gyamfi *et al.* (2022) also find that there is negative influence of financial sector development on inclusive growth under weak institutions. However, some studies evidenced positive association between BSD and economic growth and development (see Godspower-Akpomiemie and Ojah, 2017; Guru and Yadav, 2019).

On the part of the control variables, population growth has a negative and statistically significant link with HDI and the result is consistence across all the three models suggesting higher levels of population is linked with lower levels of HDI or vice versa. The possible explanation to this result is that rapid population growth strains resources, infrastructure and employment opportunities leading to lower economic productivity and slower development. High population growth without sufficient investment in human capital such as education can lead to higher poverty rates and weak economic outputs. Consistent with our priori expectation that education can lead to more inclusiveness, we evidenced positive link between this variable and HDI. Interestingly, the result

indicates that trade (all forms of measures employed) does not necessarily impact the country’s economic development in our given sample.

4.4. Robustness Checks

We employed gender development index (GDI) as an alternative measure for HDI. GDI highlights the disparities between men and women in key dimensions of development such as health, education and economic resources. Table 6 presents the regression results. In tandem with our initial findings, we document evidence that the lag of economic development (GDI) persist positively in all three models, recording statistically significance in explaining the dependent variable as shown in table 6. Again, DFI, IFI and BSDI maintained their original signs and significance across the models. In addition, the control variables also retained almost their signs and statistical significance across the models. For instance, education exhibits same relationship with the dependent variable.

Table 6. Regression Results: Two-step System GMM.

Variables	(1)		(2)		(3)	
	Coeff.	P > Z	Coeff.	P > Z	Coeff.	P > Z
LGDI	0.8270	0.000***	0.9038	0.000***	0.7588	0.000***
DFI	0.0417	0.028**	0.0420	0.041**	0.0428	0.217
IFI	-0.0328	0.002***	-0.0226	0.018**	-.0305	0.069*
BSDI	-0.0175	0.311	-0.0045	0.700	-0.0315	0.062*
POP	-0.0193	0.034**	-0.0060	0.197	-0.0285	0.024**
EDU	0.0260	0.389	0.0323	0.114	0.0552	0.423
INFL	-0.006	0.073*	-0.0002	0.431	-0.0007	0.170
BSPRD	-0.0006	0.217	-0.0003	0.574	-0.0005	0.282
EGDPR	-0.0008	0.002***				
IGDPR					-0.0011	0.036**
TRADE			-0.0004	0.829		
INSQUAL	0.0118	0.779	-0.0294	0.563	-0.0146	0.800
Model Diagnostics						
AR(1)	-2.78(0.005)		-2.88(0.004)		-2.73(0.006)	
AR(2)	-0.09(0.925)		-1.03(0.301)		0.04(0.964)	
Instruments	37		37		37	
Groups	39		39		39	
Hansen test	25.99(0.464)		30.79(0.280)		21.98(0.690)	
Sargan	20.56(0.764)		33.52(0.180)		21(0.742)	

Source: The Authors. Note: ***, ** and * significant at 1%, 5% and 10% level, respectively.

4.5. Regression Results of the Moderation Effect of Digital Finance on inclusive Finance Domestic Banking Sector Development and Economic Development Nexus

We sought as our main objective to find the moderation influence and the overall effect of digital finance on economic development. Table 7 presents the results of the moderation effects of DFI on the association between IFI, BSDI and economic development (see equations 4, 6, 8 & 9). The results indicate that DFI induces BSDI and statistically significant. Again, there emerged some variations of signs and values of coefficients as well as the significance levels of some of the variables across the three models compared to the models without the interaction (moderation) term. To obtain the net effect for the interactive terms, we took the partial derivative of the economic development (dependent variable) with respect to digital finance for all three models as shown below:

$$\frac{\partial HDI_{it}}{\partial DFI_{it}} = 0.0417 + (-0.1678)(-0.0311) + (-0.0678)(0.0139) + (0.4326)(0.0139)(-0.0311) = 0.0458$$

Where 0.0417 signifies the unconditional effect of DFI on economic development, -0.1678 represents the coefficient of the interaction of BSDI and DFI, -0.0311 is the mean of BSDI, -0.06678 is the interaction coefficient of inclusive finance and digital finance (IFI and DFI,) 0.0139 connotes the mean of IFI, 0.4326 is the coefficient of the interaction among IFI, BSDI and DFI in model1. We followed similar approach in calculating the net effect for model2 and model3 as shown below:

$$\begin{aligned} \frac{\partial HDI_{it}}{\partial DFI_{it}} &= 0.0182 + (-0.0881)(-0.0311) + (-0.0033)(0.0139) + \\ &\quad (0.1778)(0.0139)(-0.0311) = 0.0208 \\ \frac{\partial HDI_{it}}{\partial DFI_{it}} &= 0.0170 + (-0.0283)(-0.0311) + (-0.0053)(0.0139) + \\ &\quad (-0.0221)(0.0139)(-0.0311) = 0.0178 \end{aligned}$$

The values of 0.0458, 0.0208 and 0.0178 connote the coefficients of the net effects of model 1, 2 & 3 respectively. These results are indication that digital finance can spike economic development in the presence of inclusive finance and banking sector development in Africa. For instance, through digital finance, the less privileged or the unbanked and SMEs could be financially included which will boost economic activity thereby leading to improvement in economic development especially in the areas of health and education.

Table 7. Interactive Effects (Moderation of Digital Finance) Regression Results: Two-step System GMM.

		(1)		(2)		(3)	
Variables	Coeff.	P > Z	Coeff.	P > Z	Coeff.	P > Z	
LHDI	0.8798	0.000***	0.8522	0.000***	0.8860	0.000***	
DFI	0.0417	0.242	0.0182	0.480	0.0170	0.378	
IFI	0.0098	0.719	-0.0127	0.514	-0.0101	0.399	
BSDI	-0.0272	0.078*	-0.0227	0.216	-0.0083	0.643	
POP	-0.0192	0.048**	-0.0168	0.166	-0.0132	0.148	
EDU	0.0049	0.736	0.0176	0.619	0.0117	0.495	
INFL	0.0001	0.604	-0.0001	0.761	-0.0001	0.707	
BSPRD	0.005	0.103	0.0001	0.351	0.002	0.275	
EGDPR	0.0009	0.030**					
IGDPR					0.0025	0.458	
TRADE			0.0001	0.316			
INSQUAL	0.0072	0.908	-0.0002	0.993	-0.0038	0.887	
IFI*DFI	-0.0678	0.333	0.0033	0.964	-0.0053	0.920	
BSDI*DFI	-0.1678	0.019**	-0.0881	0.363	-0.0283	0.648	
IFI*BSDI*DFI	0.4326	0.410	0.1778	0.541	-0.0221	0.897	
Model Diagnostics							
AR(1)	-2.09(0.037)		-2.24(0.025)		-2.04(0.04)		
AR(2)	0.51(0.611)		0.31(0.760)		0.16(0.873)		
Instruments	37		37		37		
Groups	39		39		39		
Hansen test	21.85(0.529)		27.56(0.191)		30.78(0.128)		
Sargan	20.82(0.592)		34.54(0.043)		56.92(0.000)		

Source: The Authors. Note: ***, ** and * significant at 1%, 5% and 10% level, respectively.

5. Conclusion, Implications and Further Directions

Current issues that are widely considered by academia and policymakers across the globe are inclusive finance, digital finance, banking sector development, and economic development. Previous studies normally employed GDP as a measure of economic development. Consequently, we argued that using HDI or GDI to measure economic development gives a broader understanding of human well-being as compare to the use of GDP. We find that digital finance impacts economic development

positively across the models. With improvement in digital finance, the level of inclusive finance will improve which has the tendency to promote banking sector development and enhance economic development in Africa. The moderating role of digital finance in the inclusive finance, banking sector development and economic development nexus suggests the underlying complexities in how these factors interact in African setting. We further document evidence that inclusive finance has negative relationship with economic development due to problems such as financial literacy gaps, exclusion of vulnerable groups, limited infrastructure and short-term disruptions. Moreover, banking sector development exhibited negative relationship with economic development because the banking system in Africa is challenged with issues (inefficiencies) such as misallocation of resources, high cost of financial services and weak regulatory frameworks. On the part of the controls, population growth has a strong negative link with economic development.

The study therefore proffers that policymakers should put in more efforts in stimulating economic development since HDI in a previous year might drive more HDI in ensuing years. Second, since digital finance has become a necessary tool in helping the unbanked and the less privileged communities, and SMEs to have easy access to affordable digital services and formal financial services. African governments should collaborate with the private sector to improve digital infrastructure (e.g., build and expand mobile network coverage) by stimulating and supporting digital financial innovations. This will enhance inclusive finance, banking sector development and economic development at the long run. Third, governments and other stakeholders should design and implement targeted training programs that help equip the people with the necessary skills regarding digital financial services. Fourth, Africa must ensure that it benefit from its trade with the other trading partners so as to boost its economy. Last, governments in Africa must ensure that their population growth does not put undue pressures on their economies.

Although we document negative relationship between inclusive finance, banking sector development and economic development, we did not enquire further. We recommend future studies to investigate why such outcomes were observed. Also, we were not able to compare our results with other regions, so future studies can do comparative analysis of Africa and other regions. Notwithstanding these minor issues, the outcome of this study serves as an important basis for further studies.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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Abbreviations

- BRICS.... Brazil, Russia, India, China and South Africa
- BSD.... Banking Sector Development
- BSDI.... Banking Sector Development Index
- BSPREAD...Bank Interest Rate Spread
- CD..... Cross-sectional Dependence
- DF.....Digital Finance
- DFI.....Digital Finance Index
- EDU... Education
- EGDPR...Export to GDP Ratio
- GDI....Gender Development Index
- GDP...Gross Domestic Product

GEM.....Gender Empowerment Measure
GFDD....Global Financial Development Database
GMM....Generalized Method of Moments
GNI...Gross National Income
HDI....Human Development Index
IF.....Inclusive Finance
IFI.....Inclusive Finance Index
IGDPR....Import to GDP Ratio
IMF....International Monetary Fund
INFL...Inflation
INSQUAL.... Institutional Quality
LHDI.....Lagged of HDI
PCA....Principal Component Analysis
POP.....Population
UNDP.... United Nations Development Programme
WDI....World Development Indicators
WGI.....World Governance Indicator

Appendix A

Table A1. Panel Unit Root Tests Results.

VAR.	LLC Test		Im–Pesaran–Shin		Fisher Test		Harris-Tzavalis Test	
	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value	Test statistic	p-value
HDI	-9.0346	0.000	-6.2389	0.0000	21.2146	0.0000	0.1999	0.000*
GDI	-7.907	0.000	-1.9278	0.0269	55.7198	0.000*	0.7319	0.000*
Trade	-3.0911	0.001	-11.4372	0.000*	37.3947	0.000*	-4.7543	0.0000
EGDPR	-4.1851	0.000	-1.3508	0.0884	36.8072	0.000*	0.6856	0.0000
IGDPR	-3.2375	0.0006	-2.1348	0.0164	3.5733	0.0002	0.7025	0.0000
MSPTA	-8.1299	0.0000	-1.3860	0.0829	6.1677	0.0000	0.2518	0.000*
DPAY	-5.0428	0.0000	-9.9104	0.000*	7.0115	0.0000	0.7503	0.0002*
RPAY	-1.9811	0.0238*	-9.4223	0.000*	6.7613	0.0000	0.7630	0.0012*
BBPHTA	-6.7672	0.0000	-9.4264	0.000*	2.4202	0.0078	0.1230	0.0000*
ATMPHTA	-5.6662	0.0000	-5.4290	0.000*	4.7042	0.0000	0.3151	0.0000*
LBAPTA	-6.8042	0.0000	-11.6145	0.000*	4.2607	0.0000	0.0352	0.0000*
ATMPTK	-2.9336	0.0017	-7.2728	0.000*	12.7126	0.0000	0.2579	0.0000*
BBPTK	-6.2819	0.0000	-1.4504	0.0735	5.9435	0.0000	0.4323	0.0000*
LBCBPTA	-6.7806	0.0000	-2.7495	0.0030	6.5693	0.0000	0.0860	0.0000*
LDCBPTA	-7.6757	0.0000	-11.8488	0.000*	5.5157	0.0000	0.0540	0.0000*
DI	-3.7925	0.0001	-10.6231	0.000*	2.1886	0.0143	0.7647	0.0003
D2	-1.9240	0.0272	-10.9351	0.000*	3.4624	0.0003	0.8144	0.0757
D4	-6.5642	0.0000	-1.5057	0.0661	2.342	0.0000	0.7910	0.0088
D5	-2.2388	0.0126	-11.6505	0.000*	2.1511	0.0157	0.8009	0.0240
D6	-5.8763	0.0000	-2.2720	0.0115	10.4905	0.0000	-0.0302	0.0000*
D12	-3.5258	0.0002	0.1075	0.5428	2.0544	0.0200	0.8190	0.1057
D.D12			-11.4149	0.0000	41.3779	0.0000	-0.1450	0.0000
D14	-3.6498	0.0001	-9.9738	0.000*	3.8494	0.0001	-0.0195	0.0000*
E1	-2.8091	0.0025	-4.8664	0.0000	14.3221	0.0000	0.5269	0.000
E3	-3.3959	0.0003	-1.3149	0.0943	1.5536	0.0601	0.6975	0.000
E4	-2.2019	0.0138	-3.2298	0.0006	6.7743	0.0000	0.6279	0.0000

E7	-3.0969	0.0010	-2.7902	0.0026	3.0429	0.0012	0.5745	0.000
S1	-2.6946	0.0035	-2.9209	0.0017	3.4607	0.0003	0.7322	0.0000
S4	-3.4204	0.0003	-11.9140	0.000*	39.5511	0.0000*	0.0247	0.0000*
S6	-6.3160	0.0000	-1.4450	0.0742	5.1093	0.0000	0.7734	0.0010
S7	-2.7322	0.0031	-4.0717	0.0000	9.0797	0.0000	0.5066	0.0000
BSPREAD	-24.497	0.000*	-8.5049	0.000*	14.7431	0.0000	0.7329	0.0000
INFL	-7.1994	0.0000	-7.3193	0.0000	16.7548	0.0000	0.4577	0.0000
GDP	-8.1636	0.0000	-9.2935	0.0000	25.6435	0.0000	0.2363	0.0000
LEDU	-2.5501	0.0054	-6.8740	0.000*	14.8309	0.0000	0.1727	0.0000*
POP	-3.1735	0.0008	-5.7165	0.000*	12.9005	0.0000*	0.5678	0.0000
INSQUAL	-6.2071	0.0000	-12.2918	0.000*	2.6101	0.0045	0.0006*	0.000*

Source: Own Computations. Note: Values or variables with asterisk were first differenced.

Table A2. Principal Components Results for Digital Finance Index.

Component	Eigenvalues	Difference	Proportion	Cumulative
Comp1	2.0021	0.4356	0.4004	0.4004
Comp2	1.5665	0.9467	0.3133	0.7137
Comp3	0.6197	0.1409	0.1239	0.8376
Comp4	0.4788	0.1458	0.0958	0.9334
Comp5	0.3330		0.0666	1.0000

Source: The Authors.

Table A3. Principal Components Results for Inclusive Finance Index.

Component	Eigenvalues	Difference	Proportion	Cumulative
Comp1	2.7806	1.7697	0.5561	0.5561
Comp2	1.0109	0.3333	0.2022	0.7583
Comp3	0.6776	0.3571	0.1355	0.8938
Comp4	0.3205	0.1101	0.0641	0.9579
Comp5	0.2104		0.0421	1.0000

Source: The Authors.

Table A4. Principal Components Results for Banking Sector Development Index.

Component	Eigenvalues	Difference	Proportion	Cumulative
Comp1	6.4325	4.1038	0.4288	0.4288
Comp2	2.3287	0. 9401	0.1552	0.5841
Comp3	1.3886	0.2416	0.0926	0.6767
Comp4	1.1470	0.2182	0.0765	0.7531
Comp5	0.9288	0.1040	0.0619	0.8150
Comp6	0.8248	0.2310	0.0550	0.8700
Comp7	0.5939	0.1284	0.0396	0.9096
Comp8	0.4654	0.1167	0.0310	0.9407
Comp9	0.3485	0.1020	0.0232	0.9639
Comp10	0.2465	0.1296	0.0164	0.9803
Comp11	0.1168	0.0421	0.0078	0.9881
Comp12	0.0748	0.0178	0.0050	0.9931
Comp13	0.0570	0.0255	0.0038	0.9969
Comp14	0.0315	0.0162	0.0021	0.9990
Comp15	0.0153		0.0010	1.0000

Source: The Authors

Table A5. Cross-sectional Dependence Tests Results.

No.	Test	Test Statistic	P-Value	Decision
1	Pesaran	6.911	0.070	Failed to reject Ho
2	Friedman	45.869	0.1782	Failed to reject Ho
0.059				
3	Frees	Critical values from Frees' Q distribution alpha = 0.10: 0.1719 alpha = 0.05: 0.2262 alpha = 0.01: 0.3351		Failed to reject Ho at all levels of alpha

Table A6. Countries for the study.

GHANA	NAMIBIA	UGANDA	GUINEA
NIGERIA	MAURITIUS	MALAWI	LIBERIA
KENYA	BOTSWANA	MADAGASTER	ETHIOPIA
MAURITANIA	SOUTH AFRICA	MOZAMBIQUE	CHAD
MOROCCO	GABON	MALI	CONGO, DEM. REP.
ANGOLA	LIBYA	RWANDA	SUDAN
ALGERIA	ZIMBABWE	ZAMBIA	BURKINA FASO
SENEGAL	CONGO REP	NIGER	SIERRA LEONE
TANZANIA	BENIN	TOGO	COTE DIVOIRE
TUNISIA	CAMEROON	EGYPT	

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