



The interconnectedness of digital finance, financialization, and financial inclusion: Evidence from Sub-Saharan Africa

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ABSTRACT

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The purpose of this study is to examine the interplay among digital finance, financialization, and financial inclusion using panel data from a sample of 29 sub-Saharan African countries. The data cover a period of 10 years from 2013 to 2023 and were retrieved from the World Bank database. Autoregressive distributed lag with an error correction model (ARDL-ECM) was employed to analyze the data. The findings reveal a nuanced interplay among the variables. In the long run, (1) digital finance has no significant effect on financial inclusion; (2) digital finance has a significant positive effect on financialization; and (3) financialization promotes financial inclusion. The short-run Granger causality test further reveals a unidirectional causality running from financialization to digital finance; a bidirectional causality running from digital finance to financial inclusion and from financial inclusion to digital finance; and a bidirectional causality running from financialization to financial inclusion and from financial inclusion to financialization. Overall, our findings are robust to several diagnostic tests.

Contribution/Originality: The study clarifies the long-standing debate on financial inclusion in Sub-Saharan Africa, providing empirical evidence and practical approaches to guide governments and international organizations in their efforts to integrate marginalized populations into formal financial systems. It contributes toward the attainment of four Sustainable Development Goals (Goals 1, 8-10).

1. INTRODUCTION

Prior to the emergence of financial inclusion (FI) in the early 2000s, many individuals globally faced financial resource limitations, affecting their socioeconomic well-being. This prompted researchers, governments, and international organizations to focus on bridging the poverty-inclusive growth gap (Girard, 2021). In the emerging economies of sub-Saharan Africa (SSA), access to basic financial services is a mirage as a significant proportion of the population lives in abject poverty, especially those who are rural-bound. According to Telukdarie and Mungar (2023), emerging countries' drive for FI can be achieved with the transformative capabilities of digital finance (DF). DF has transformed the financial ecosystem by enabling individuals in remote areas to access financial services such as savings, interoperability, withdrawals, and online payments without the need to be physically present in a bank. In particular, between 2011 and 2021, there was an increase in savings among global adults, with 1.4 billion adults (76%)

possessing savings accounts. The comparison between developed and developing countries' savings rates reveals a significant disparity: 58% for developed countries and 25% for developing countries (World Bank, 2025).

The low savings rate in developing countries provides substantial evidence of the need to improve equitable access to financial services to bridge the financial inclusion (FI) gap in Sub-Saharan Africa (SSA), despite the positive impact of digital finance (DF) on gender disparity in the region (World Bank, 2025). According to Kumar and Ahuja (2025), a systematic review indicates that the concept of FI is still evolving in developing countries, as previous studies on FI are skewed toward developed nations. Consequently, our study addresses a significant evidence gap regarding how SSA countries achieve FI through DF. Although the DF–FI nexus has been extensively researched in various countries (Al-Smadi, 2023; Bede Uzoma, Omankhanlen, Obindah, Arewa, & Okoye, 2020; Menza, Jerene, & Oumer, 2024; Shen, Hueng, & Hu, 2021; Thathsarani & Jianguo, 2022; Umar, Baita, Hamadou, & Abduh, 2025), no study has examined the mediating role of financialization in this relationship. From a post-Keynesian perspective, factors such as demand, economic systems, and income distribution are adversely affected by a country's financialization drive (Alexiou, Trachanas, & Vogiazas, 2022; Epstein, 2005; Tridico & Pariboni, 2018). Our study is novel because it explores the interconnectedness of DF, FI, and financialization in the SSA region.

Finally, most studies on the positive or negative link between DF and financialization, as well as financialization and FI, are conceptual or theoretical in nature (Correa & Girón, 2019; Gronbach, 2023; Zou, 2024). Our study is the first to present objective data to verify these propositions. Although some studies have objectively examined the relationship between financialization and investment (Davis, 2018; Gong, Gong, & Jiang, 2023; Tori & Onaran, 2018), they focused on micro- or firm-level analysis of the non-financial sector. In contrast, our study emphasizes macro-level analysis of the financial sector. Consequently, we aim to validate the triadic relationship among DF, FI, and financialization, seeking to answer three research questions.

RQ1. Does digital finance significantly affect financial inclusion in SSA?

RQ2. To what extent does digital finance affect financialization in SSA?

RQ3. What is the effect of financialization on financial inclusion in SSA?

Our study contributes to the existing body of work across three distinct domains. First, our study contributes to the current body of literature on DF and FI within the context of developing economies, particularly in SSA. The study fills a gap in what is not known, providing fresh, large-scale insights into how financialization shapes the DF–FI nexus across several countries in SSA. Second, we build on the World Bank's FI efforts and offer practical ways to tackle poverty in developing nations. The findings can broaden policymakers' horizons on contemporary DF: what is working, what is not, and how to reach marginalized populations. They can also provide a clearer picture of the risks tied to embracing digital financial services. Ultimately, at its core, FI drives progress on four of the UN's 17 Sustainable Development Goals. It stimulates innovation (Goal 9), particularly in the realm of Fintech, which creates job opportunities and economic prosperity (Goal 8), empowers women by addressing inequalities (Goal 10), and contributes to the eradication of poverty (Goal 1).

The subsequent sections of the manuscript are organized as follows: Section two reviews the theoretical and empirical literature on the variables under investigation. Section three explains and justifies sample selection, data sources, variable measurements, and econometric modeling. Sections four and five report and discuss the results, respectively, while section six concludes the study with policy implications, highlighting limitations, and offering suggestions for further research.

2. LITERATURE REVIEW

2.1. Digital Finance

Digital finance means using digital platforms and technology; think internet banking, fintech apps, mobile money, and blockchain to deliver financial services (Pazarbasioglu et al., 2020). With these new tools in the mix, financial products get cheaper, easier to access, and a whole lot more efficient. Old-school banking products have gone digital

too (Gomber, Koch, & Siering, 2017). In places where traditional banks barely exist, DF has changed everything. Now people and businesses can handle payments, get credit, save money, and buy insurance, all without stepping into a physical branch. In emerging economies, mobile money has enabled marginalized populations to be integrated into the financial system due to its speed and scalability features (Ozili, 2018). Several studies have alluded to the benefits of digital financial services in resource-poor countries, such as removing income barriers, reducing transaction costs, and facilitating governments' efforts to achieve economic stability (Donovan, 2012; Misati, Osoro, Odongo, & Abdul, 2024). Concurrently, inherent challenges such as breach of privacy, cybersecurity issues, and illiteracy (Ediagbonya & Tioluwani, 2023) can impede the transformative potential of DF if not addressed.

2.2. Financialization

From a macroeconomic perspective, financialization refers to the rapid growth or expansion of a country's financial systems, such as banks, non-bank financial firms, and stock exchange markets (Palley, 2013). According to Liu, Jin, Liu, and Wan (2023), the degree of a company's growth is not solely tied to increasing production and sales but also to how it manages its financial resources. While financialization holds immense promise to stimulate product innovation through improved access to financial resources, these benefits may be constrained by systemic inequality that favors the upper class and marginalizes the lower class (Van der Zwan, 2014). Gronbach (2023) contends that inclusive growth is possible, given that, as financial systems expand in response to demand, they fuel the development of digital platforms, enabling quick access to capital. For example, in the context of SSA, many mobile money centers, bank branches, and ATMs can be found in virtually every community or locality, enabling real-time transactions. According to Krippner (2012), sustaining financialization without crippling economic growth and keeping in check systemic inequality requires the enforcement of laws and regulations.

2.3. Financial Inclusion

In its simplest form, FI is a holistic approach adopted by governments in collaboration with international partners to eliminate obstacles to financial sector participation, ensuring equitable access to credit, savings, and investment products, especially for marginalized populations (Demirgüç-Kunt, Klapper, Singer, Ansar, & Hess, 2020; World Bank, 2025). Kim, Zoo, Lee, and Kang (2018) contend that economic growth is directly related to FI for two reasons. First, FI bridges the income-poverty gaps, enabling individuals to improve their socioeconomic well-being. Second, when more people participate in the financial system, risks are spread evenly, transaction costs are reduced, and financial service providers accumulate more deposits, some of which they lend to the government to carry out its activities. FI and DF are also interlinked, transforming the financial ecosystem. For example, fintech and mobile money have changed the game, especially in SSA, where traditional banking, though still common, is the least patronized (Donovan, 2012; Ediagbonya & Tioluwani, 2023). Even with all this progress, gaps remain across gender, geography, and income (World Bank, 2025), necessitating strategic policies that address technological, cultural, and socioeconomic barriers.

2.4. Theoretical Framework

This study adopts Rogers, Singhal, and Quinlan's (2014) Diffusion of Innovation (DOI) theory to explain the interrelation among DF, financialization, and FI. According to DOI theory, trialability, observability, relative advantage, compatibility, and complexity are factors influencing how new technologies are adopted over time as they spread through a social system (Rogers et al., 2014). DF, comprising fintech platforms, agent banking, and mobile money, represents a financial innovation that is transforming how individuals, especially the marginalized, access and use financial services. The dissemination of any innovation depends on five factors, as per DOI theory: the innovation, the adopters, communication channels, time, and the social system (Minishi-Majanja & Kiplang'at, 2005). Unlike the technology acceptance model (TAM), innovation adopters encompass socially connected organizations and groups as

well as individuals (Al-Smadi, 2023). The DOI theory is especially pertinent to FI, as it emphasizes the significance of adoption dynamics in mitigating financial exclusion. Since its emergence, the utilization of DF platforms has favored the rich and literates in advanced countries compared to the urban poor and illiterates in less developed countries (Ondiege, 2013).

Achieving FI is possible when DF platforms are cost-effective, easy to use by the less educated, safeguard user privacy, and are patronized by a large segment of the population (Asongu & Odhiambo, 2019). When reversed, DF platforms that are costly, difficult to use, breach users' privacy, and are less patronized due to trust issues, combined with poor digital infrastructure, can obstruct FI attainment (Ediagbonya & Tioluwani, 2023; Sikka & Bhayana, 2024). Thus, DOI theory helps explain how the pace and pattern of new technology adoption shape who gets access and who does not. DOI theory does not just highlight where the gaps are; it points to how DF can be rolled out more strategically, closing those gaps and pushing FI forward in different socioeconomic settings.

2.5. Digital Finance and Financial Inclusion

There is a general consensus among several researchers regarding the positive effect of DF on FI. The majority of prior studies took a cross-country approach to analysis, which, although yielding generalizable findings, lacks country-specific insight. An earlier study by Siddik and Kabiraj (2019), which covered 189 countries, found that DF significantly affects FI. The main strength lies in the large sample size, which improved the predictive power of the explanatory variables. However, the results cannot be extrapolated to single countries due to institutional and digital infrastructure variances that determine DF implementation. Analyzing 27 countries in SSA, Bede Uzoma et al. (2020) anchored a positive effect, suggesting DF promotes FI. While sourcing data from the World Bank enhanced the consistency and transparency of the reported findings, failing to account for informal financial practices risks excluding marginalized populations that dominate the continent. Expanding the sample size to 101 countries, Shen et al. (2021) found that DF's beneficial effects are more prominent in emerging countries compared to developed countries but failed to unveil the underlying mechanisms.

In their study examining the determinants of FI using a cross-section of 366 SMEs based in Sri Lanka, Thathsarani and Jianguo (2022) confirmed the positive role of DF in promoting FI and improving overall SME performance. An inherent limitation in their study is the issue of self-reporting bias associated with conducting questionnaire surveys. Recognizing this limitation, the study by Al-Smadi (2023) employed the system-generalized method to document a positive DF–FI nexus in the MENA region. While the study's generalization contributes to theory, the findings cannot be extrapolated to a single country due to technological and regulatory diversity. More recently, Menza et al. (2024) sought to address this lack of research at the country level by exploring the DF–FI nexus in Ethiopia. The findings strongly support prior studies on the positive impact of DF platforms, such as ATMs, fintech, agents, and mobile banking on FI. Building upon (Thathsarani & Jianguo, 2022) seminal work, Umar et al. (2025) extend the discussion to Africa SMEs and report that DF significantly improves SME FI. However, they did not clearly distinguish between various categories of DF.

In theory, the link between DF and FI starts with something simple: most people who are excluded from traditional banking already have mobile phones. When financial market players bring financial services to those phones, they open real doors for individuals who have been left out (Islam, Ornob, & Hossain, 2025). If a person has a mobile device and affordable internet, DF does not just help; it changes the game for FI. People can pay their bills, send money, and handle everyday transactions straight from their phones (Ozili, 2018). It, however, goes further. When DF platforms are easy to use, people do not just keep that knowledge to themselves. They show others (e.g., family, friends, coworkers) how it works, spreading access across both formal and informal networks. As more people jump on board, DF grows, and FI gets stronger. It is a ripple effect: better tech, more access, and broader inclusion. Combining empirical findings and theoretical arguments, we hypothesize that:

H: Digital finance is positively related to financial inclusion.

2.6. Digital Finance and Financialization

Empirical studies on the relationship between DF and financialization are scarce. Until recently, few studies have emerged in which the ramifications for company financial conduct, especially in the area of SMEs financialization, are receiving attention. A study by Gao and Ren (2023) explores how DF promotes financialization of Chinese SMEs and found that DF inhibits financialization. In other words, the proclivity of companies to switch from risky financial operations to essential investments that generate satisfactory returns hinges on enhanced DF access. A unique strength of the study lies in the large sample size, which produced better estimates and generalization; however, other developing countries lacking the necessary digital infrastructure may struggle to catch up with the DF craze. In a related study, Liu et al. (2023) found that DF impedes financialization but acts as an intermediary to positively affect operational performance. In essence, the finding suggests that increasing investment in DF does not always procure the intended financialization benefits.

The capability of DF platforms to integrate marginalized populations into a country's financial ecosystem is likely to result in increased financialization, given that financialization thrives on the backbone of technology Omowole, Urefe, Mokogwu, and Ewim (2024). In financial economics, digital technologies are known to eliminate long-standing barriers to financial market participation, such as high capital and bureaucratic regulatory processes. This enables the expansion of financial services by service providers and facilitates prudent personal finance decisions by users (Pazarbasioglu et al., 2020; Werth, Schwarzbach, Rodríguez Cardona, Breitner, & Graf von der Schulenburg, 2020). Additionally, evidence from Putrevu and Mertzanis (2024) shows that DF technologies reduce transaction costs, and Chitturi (2025) argues that individuals and small businesses leverage DF technologies to access credit without collateral formalities, reinforcing the positive impact of DF on financialization.

Moreover, the expansion of financial markets and the resulting increased participation occur through digitally enabled features such as gamification, which advances financial literacy by providing real-time access to market information (Gaur, Gupta, Tiwari, & Pal, 2025). In addition to gamification being a game-changer, wealth redistribution is now possible with the emergence of automated chat robots that provide investment advice for low-income earners interested in growing their portfolios (Adetokunbo & Idowu, 2025; Tan, 2020). Through their role in enhancing equitable financial product pricing, these technologies mitigate financialization risks (Alonge et al., 2023). With financialization being a driver of economic growth, the transformative potential of DF to reduce marginalization and promote access to the wider financial ecosystem cannot be overemphasized. Therefore, we postulate that:

H₂: Digital finance is positively related to financialization.

2.7. Financialization and Financial Inclusion

Empirical studies on the relationship between financialization and FI are scarce, as many of the prior studies are conceptual in nature. The conceptual arguments tend to support the positive role of financialization in promoting FI. For example, Udohaya (2025) posits that digital platforms not only stimulate product innovation within the financial ecosystem but also serve as the driving force behind the expansion of the financial system to improve access to and coverage of marginalized populations. The extensive coverage of marginalized populations saves time and reduces cost for both the service provider and the service user (Sung, 2025). Financialization is inextricably linked to financial intermediation (Levine, 2005), suggesting that increased participation in credit or capital acquisition is driven by the scope of expansion of financial institutions.

Furthermore, an essential element of economic growth is innovation, which arises when firms compete with each other for scarce resources (Schumpeter & Swedberg, 2021). Based on this logic, integrating marginalized populations into the wider financial system requires designing products tailored to their specific needs (Gronbach, 2023). While meeting such needs comes at a cost, the risk premium is comparatively higher because achieving the financialization inclusion goal is a risky endeavor, and high risks usually come with high rewards in financial market settings (Adelaja, Umeorah, Abikoye, & Neziyanya, 2024; Demirgüç-Kunt et al., 2020). Nevertheless, certain financial theorists such as

Palley (2013) and Van der Zwan (2014) warn about the dangers of speculation. Collectively, FI does not occur in a vacuum; it is driven by competitive forces that propel the expansion of financial systems within the framework of innovation. Therefore, we postulate that:

H₃: Financialization is positively related to financial inclusion.

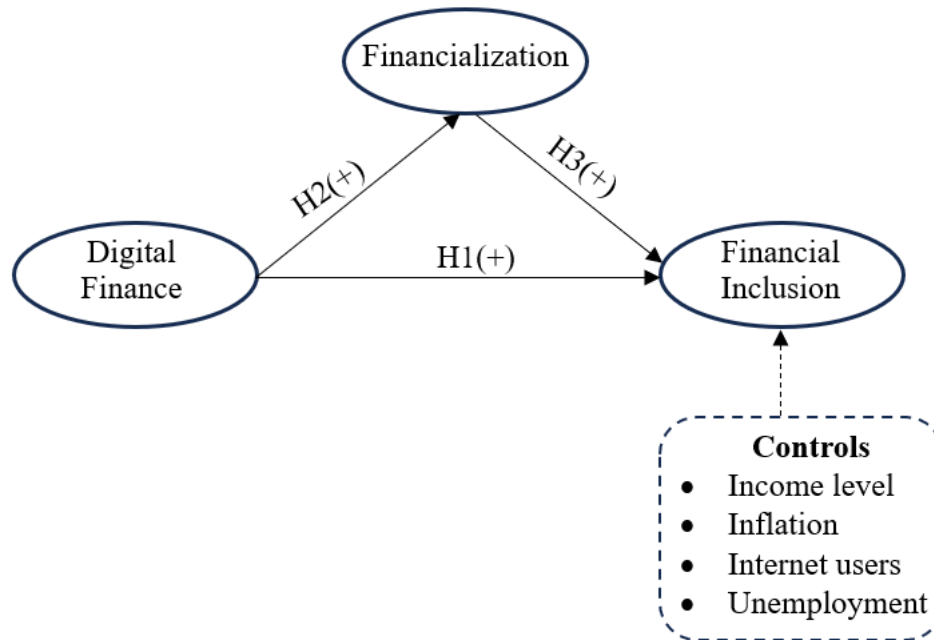


Figure 1. Research model.

Figure 1 presents the model of the study, which illustrates the relationship among digital finance, financialization and financial inclusion in Sub-Saharan Africa.

3. METHODS

3.1. Sample Selection and Data Source

There are 49 countries in SSA, out of which we purposively selected 29 countries that had the requisite data covering the period from 2013 to 2023. The list of selected countries is summarized in Table 1. Regarding the data source, we retrieved the longitudinal data from the World Bank, which is an open access databank. We opted to use secondary data from the World Bank because of its credibility and decades of experience in the computation of statistical estimates covering many macroeconomic variables for all countries in the World. Since our study is conducted at the cross-country level, using longitudinal data from the World Bank minimizes self-evaluation bias, increases data quality, and improves the generalizability of findings.

Despite obtaining data from a credible source, cross-country data are often fraught with outliers and to solve this issue, we implement certain inclusion and exclusion criteria. Initially, we identify countries that possess a minimum of five consecutive observations for the dependent variable (FI), a criterion that is also essential for econometric analysis (Roodman, 2009). Secondly, we exclude any countries that exhibit a consistently negative mean FI over the period under study. Ultimately, we eliminate observations that fall within the upper and lower 1% of the distribution for each variable. Overall, we obtained more than half (59%) of the target population as our sample size, which is adequate for generalization.

Table 1. Sample distribution.

Lower-income countries	Lower-middle-income countries	Upper-middle-income countries
Chad	Benin	Botswana
Guinea	Burkina Faso	Mauritius
Guinea-Bissau	Cameroon	Namibia
Mali	Cape Verde	
Madagascar	The Republic of Congo	
Niger	Cote d'Ivoire	
Rwanda	Comoros	
Togo	Djibouti	
Uganda	Eswatini	
Zimbabwe	Ghana	
	Lesotho	
	Mauritania	
	Nigeria	
	Sao Tome and Principe	
	Senegal	
	Zambia	
Total = 10	Total = 16	Total = 3

3.2. Variable Measurements

3.2.1. Digital Finance

In this study, DF is the independent variable. In developing and emerging economies, the banking sector serves as a fundamental pillar and the most significant contributor to the development of DF. Consequently, our attention is directed toward the development of DF by commercial banks. Following Al-Smadi (2023) and Bede Uzoma et al. (2020), we measured DF as the “proportion of individuals using ATMs per 100,000 adults.”

3.2.2. Financialization

Financialization is the mediator variable. Financialization, as defined earlier, is the growing dominance of financial markets, institutions, and incentives. In the absence of data covering financial markets for the samples, we shifted the focus to financial institutions, specifically, commercial banks. Accordingly, we measured financialization as the “number of commercial bank branches per 100,000 adults.” We chose commercial bank branches as a proxy for financialization because they mirror the effects, both positive and negative, of a growing financial sector on economic systems, demand, income distribution, and investment (Epstein, 2005).

3.2.3. Financial Inclusion

The dependent variable is FI. Following the recommendation of the World Bank (2025) and the research by Al-Smadi (2023) and Bede Uzoma et al. (2020), we settle on the “access” dimension of FI, defining it as a systematic approach designed to broaden the financial network for individuals, encompassing those who are unbanked and underbanked. Accordingly, we measured FI as “depositors with commercial banks per 1000 adults.”

3.2.4. Control Variables

To reduce omitted variable bias, four control variables are included to predict their impact on FI in the SSA region. GDP per capita serves as a proxy for income level, reflecting the socioeconomic well-being of a country's labor force involved in production during a specific year. It is expected that FI will decline as income levels increase among individuals in SSA, indicating a negative relationship between income and FI.

Many individuals in resource-poor countries of SSA struggle to afford basic necessities; hence, we introduce “inflation” to capture the annual increase or decrease in the prices of consumer goods and services. We anticipate that high inflation rates, which are common in SSA, will reduce the purchasing power of a country's populace, decrease the value of money, and ultimately hinder FI (Al-Smadi, 2023).

Another important variable we controlled for is 'Internet usage,' which indicates the percentage of a country's population with Internet access. According to Sha'ban, Girardone, Sarkisyan, and Arun (2023), marginalized populations become integrated into the financial ecosystem driven by digital infrastructure expansion, improving their access to digital financial services. Thus, we anticipate Internet usage to positively affect FI.

Finally, our model is strengthened with the integration of “unemployment.” Evidence suggests that financial inclusion can reduce unemployment in developing countries (Mehry, Ashraf, & Marwa, 2021). In this sense, a high unemployment rate leads to financial exclusion because it affects the ability of individuals to save or access financial products from financial institutions. Therefore, we anticipate a negative effect of unemployment on FI. Table 2 summarizes the variables and their source.

Table 2. Variables, measurement, and their source.

Category	Name of variables	Legend	Measurement	Source
Independent variable	Digital Finance	DF	ATMs per 100,000 adults	FAS ^a
Dependent variable	Financial Inclusion	FI	Depositors with commercial banks per 1000 adults	FAS
Mediating variable	Financialization	FN	Commercial bank branches per 100,000 adults	FAS
Control variables	Income Level	IL	GDP per capita (constant 2015 US\$)	WDI ^b
	Inflation	IFL	Consumer prices (annual %)	WDI
	Internet usage	INT	Individuals using the Internet (% of population)	WDI
	Unemployment	UE	Unemployment, total (% of the total population)	ILOEST ^c

Note: a. World Bank publication of IMF's financial access survey (FAS).
b. World Bank publication of world development indicators (WDI).
c. ILOEST stands for International Labor Organization Modeled Estimates issued by the International Labor Organization and published by the World Bank.

3.3. Econometric Modeling

Following Pesaran, Shin, and Smith (1999), we employ the panel Autoregressive Distributed Lag Error Correction Model (ARDL-ECM) to estimate the coefficients of the variables under consideration. In contrast to traditional panel regression techniques (Arellano & Bond, 1991), ARDL-ECM effectively addresses the challenges posed by heterogeneity, endogeneity, and country-specific effects within a diverse sample of countries. Our data is specifically a short panel because the time dimension (T) is less than the individual dimension (N). Therefore, we constructed the following models.

$$\log FN_{it} = \beta_0 + \beta_1 \log DF_{it} + \beta_2 \log FI_{it} + \beta_3 \log IL_{it} + \beta_4 \log IFL_{it} + \beta_5 \log INT_{it} + \beta_6 \log UE_{it} + \varepsilon_{it} \quad (1a)$$

$$\Delta \log FN_{it} = \sum_{k=1}^2 \beta_{ik} \Delta \log FN_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log DF_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log FI_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log IL_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log IFL_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log INT_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log UE_{i,t-k} + \lambda_{ik} \varphi_{i,t-1} + \omega_i + \varepsilon_{it} \quad (1b)$$

$$\log FI_{it} = \beta_0 + \beta_1 \log DF_{it} + \beta_2 \log FN_{it} + \beta_3 \log IL_{it} + \beta_4 \log IFL_{it} + \beta_5 \log INT_{it} + \beta_6 \log UE_{it} + \varepsilon_{it} \quad (2a)$$

$$\Delta \log FI_{it} = \sum_{k=1}^2 \beta_{ik} \Delta \log FI_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log DF_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log FN_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log IL_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log IFL_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log INT_{i,t-k} + \sum_{k=0}^5 \alpha_{ik} \Delta \log UE_{i,t-k} + \lambda_{ik} \varphi_{i,t-1} + \omega_i + \varepsilon_{it} \quad (2b)$$

Where FN_{it} , FI_{it} , and DF_{it} denote financialization, financial inclusion, and digital finance of country i at time t . IL_{it} , IFL_{it} , INT_{it} , and UE_{it} are the control variables, namely, income level, inflation, Internet users, and unemployment, respectively; k values (number of lags) range from 0 to 5; α_{ik} is the coefficients of the predictors; β_{ik} is the coefficients of each lagged dependent variable; ω_i is the country-specific fixed effects term; $\varphi_{i,t-1}$ is the error correction; and ε_{it} is the scholastic error. The “a priori” expectation is that the error correction coefficient (λ_{ik}) should be significantly negative.

Equations 1a and 2a test the long-run relationship, while Equation 1b tests the short-run relationship, specifically the effects of the lagged first-differenced FN and predictors (independent and control variables) on the current period

of FN. On the other hand, Equation 2b tested the effects of the lagged first-differenced FI and predictors on the current period of FI. The analysis was conducted using the EViews software, version 12.

4. RESULTS

4.1. Descriptive Analysis

The descriptive summary of the raw data is presented in Table 3. The average number for digital finance is 14, indicating limited access to ATMs for digital cash among adults. Regarding financialization, there is no variation across countries in the sample, as shown by a mean of 6.86 and a standard deviation of 6.85 for commercial bank branches. However, variability exists in financial inclusion, with a mean of 429.02, a standard deviation of 485.69, a minimum of 24.67, and a maximum of 2057.23. This suggests that access to bank deposits and withdrawals differs across countries. Among control variables, income level exhibits the highest standard deviation, reflecting differences in GDP per capita within the SSA region, ranging from US\$422.92 to US\$10,956. Conversely, unemployment shows the lowest standard deviation.

Table 3. Results of the descriptive statistics.

Variables	Code	N	Mean	Std. Deviation	Minimum	Maximum
Digital Finance	DF	282	14.000	16.177	0.763	75.579
Financialization	FN	282	6.857	6.850	0.845	32.087
Financial Inclusion	FI	282	429.022	485.693	24.671	2057.228
Inflation	IFL	282	8.100	37.252	-3.233	557.202
Income Level	IL	282	2019.700	2008.469	422.924	10956.95
Internet Users	INT	282	27.160	19.055	1.250	81.400
Unemployment	UE	282	8.509	7.522	0.418	28.138

4.2. Unit Root Test

In conducting the unit root test, we use the Fisher-type Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, which assume cross-sectional independence across units. Table 4 displays the results. DF and unemployment are stationary at their levels, while other variables become stationary after first differencing. Given the mix of I(0) and I(1) variables, the null hypothesis of a unit root is rejected.

Table 4. Results of the unit root test.

Variables	ADF		PP	
	Level	1 st Diff.	Level	1 st Diff.
logDF	107.113***	128.648***	185.164***	175.761***
logFN	63.354	85.918***	118.438***	220.431***
logFI	22.739	96.313***	38.024	192.965***
logIFL	42.939	75.368***	50.309	114.752***
logIL	39.395	102.086***	59.290	164.604***
logINT	60.669	74.443*	161.888***	162.688***
logUE	88.611***	122.144***	77.298**	131.701***

Note: ***, **, and * denote significance at the 1%, 5%, and 10%, respectively.

4.3. Regression Results

A major criterion that needs to be met prior to conducting ARDL analysis is to test the existence of co-integration between the predictors and outcome variable. As presented in Table 5, it is clear that I(0) and I(1) critical values are less than the absolute value of the F-statistic. Based on this evidence, the null hypothesis, which assumes no co-integration, is rejected.

In the long run (see Table 6), DF is positively and significantly related to financialization in Model 1. This indicates that a 1% increase in DF results in a 75.49% rise in commercial bank branches. In Model 2, DF does not

significantly impact financial inclusion (FI), but financialization shows a significant positive effect. According to Baron and Kenny (1986), mediation analysis, financialization fully mediates the relationship between DF and FI. This suggests that focusing solely on DF does not improve financial inclusion; instead, combining it with financialization by expanding bank branches to the unbanked can increase FI by 57.13%. Among control variables, unemployment negatively affects FI, while inflation, income level, and Internet usage positively influence FI.

In the short run (Table 7), the speed of adjustment (ECM) in models 1 and 2 has the expected negative sign and is statistically significant, confirming that the variables are cointegrated. In model 1, the ECM coefficient is -0.9550, indicating that approximately 95.50% of deviations from the long-term equilibrium are corrected annually. In this model, the coefficients of digital finance, income level, inflation, Internet users, and unemployment differ in their effects on financialization compared to the long-term coefficients. Therefore, the ECM adjusts discrepancies between short- and long-term estimates, with financialization correcting at a rate of 95.50% per year in response to shocks in the predictors. In model 2, the ECM coefficient is -0.9786, suggesting that about 97.86% of deviations from equilibrium are corrected annually. Here, the coefficients of digital finance, financialization, income level, inflation, Internet usage, and unemployment have effects on financial inclusion that differ from their long-term impacts.

We also conducted a Granger causality test (Table 8), revealing a one-way causality from financialization to DF; a two-way causality from DF to FI as well as from FI to DF; and finally, a two-way causality from financialization to FI as well as from FI to financialization.

To ensure our results are robust, we conducted several diagnostic checks (Table 9) involving the short-run Wald test, serial correlation, heteroskedasticity, cumulative sum (CUSUM), and CUSUM of Squares. At the 5% significant level, the Wald test's p -value is lower, indicating that the predictors jointly influence the outcome variable in models 1 and 2. Similarly, at the 5% significant level, Breusch-Godfrey serial correlation test's p -value is higher, suggesting serial correlation is completely absent. Furthermore, at the 5% significant level, ARCH heteroskedasticity test's p -value is higher. Based on this evidence, the null hypothesis, which assumes no ARCH effects in the residuals is accepted. This means that the residuals exhibit homoskedasticity and the model is correctly specified. Finally, the CUSUM and CUSUM of Squares plots (in blue) in Figures 2 and 3 are within the red critical band (5% significance), and there are no outliers. Therefore, we accept the null hypothesis that the models' coefficients or parameters are stable over time.

Table 5. Bound testing approach to cointegration.

	Model 1			Model 2		
	Value	I(0)	I(1)	Value	I(0)	I(1)
F-statistic	19.661	2.26	3.35	29.328	1.75	2.87
		2.62	3.79		2.04	3.24
		2.96	4.18		2.32	3.59
		3.41	4.68		2.66	4.05

Table 6. Results of the long-run model.

Variables	Model 1		Model 2	
	Coefficient	Std. Error	Coefficient	Std. Error
logDF	0.7549***	0.1336	-0.3677	0.2386
logFN	-	-	0.5713***	0.2099
logIFL	-0.0363	0.0299	0.1420***	0.0479
logIL	-0.0925	0.1351	0.7316***	0.0378
logINT	0.005	0.0595	0.3475***	0.0697
logUE	0.2451***	0.0875	-0.6530***	0.1077

Note: In Model 1, the dependent variable is logFN; in Model 2, the dependent variable is logFI; *** denotes significance at the 1%; Akaike Information Criterion (AIC) guided the selection of the optimal model; and the maximum lag is 5.

Table 7. Results of the short-run model.

Variables	Model 1		Model 2	
	Coefficient	Std. Error	Coefficient	Std. Error
$\Delta(\log FN(-1))$	0.0986	0.0694	-	-
$\Delta(\log DF)$	0.5924***	0.0456	0.2288***	0.0848
$\Delta(\log DF(-1))$	-	-	0.5474***	0.1163
$\Delta(\log DF(-2))$	-	-	0.3351**	0.1291
$\Delta(\log FN)$	-	-	0.8027***	0.0707
$\Delta(\log FN(-4))$	-	-	0.2746***	0.0757
$\Delta(\log IFL)$	-0.0014	0.0164	-	-
$\Delta(\log IFL(-3))$	-	-	-0.0732**	0.0305
$\Delta(\log IFL(-4))$	-	-	-0.0632**	0.0246
$\Delta(\log IL)$	-	-	0.2814***	0.0702
$\Delta(\log IL(-1))$	0.0989*	0.0549	-	-
$\Delta(\log INT)$	0.3030***	0.0532	-0.1234*	0.071
$\Delta(\log INT(-2))$	0.1313**	0.0514	-	-
$\Delta(\log INT(-3))$	0.156***	0.0458	-	-
$\Delta(\log UE)$	-	-	-0.2050***	0.0417
$\Delta(\log UE(-1))$	-0.0978**	0.0461	-	-
$\Delta(\log UE(-2))$	-0.1810***	0.040	-	-
$\Delta(\log UE(-3))$	-0.2166***	0.0291	-	-
ECM	-0.9550***	0.0869	-0.9786***	0.0667

Note: In Model 1, the dependent variable is $\Delta \log FN$; in Model 2, the dependent variable is $\Delta \log FI$; Δ denotes first difference; ***, **, and * denote significance at the 1%, 5%, and 10%, respectively; ECM is the error correction model; Akaike Information Criterion (AIC) guided the selection of the optimal model; and maximum lags is 5.

Table 8. Granger causality test.

Null Hypothesis	Observations	F-Statistic	Direction
LogDF does not Granger Cause LogFN	280	0.5147	Unidirectional
LogFN does not Granger Cause LogDF	-	4.7992***	-
LogDF does not Granger Cause LogFI	280	13.810***	Bidirectional
LogFI does not Granger Cause LogDF	-	5.7055***	-
LogFN does not Granger Cause LogFI	280	8.5848***	Bidirectional
LogFI does not Granger Cause LogFN	-	6.6656***	-

Note: *** indicate that the coefficient is statistically significance at the 1% level.

Table 9. Diagnostics test.

Variables	Model 1		Model 2	
	Obs.*R-square	p-value	Obs.*R-square	p-value
Wald test	26.409	0.000	3.9401	0.001
Breusch-Godfrey serial correlation	4.3298	0.115	0.458	0.795
Heteroskedasticity (ARCH)	2.7182	0.099	1.5529	0.213
CUSUM	Stable	-	Stable	-
CUSUM of Squares	Stable	-	Stable	-

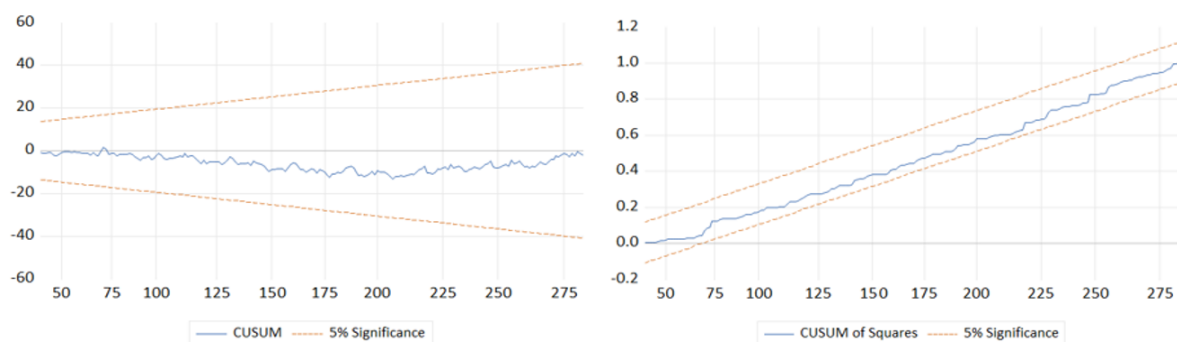


Figure 2. Graphs of model 1 stability diagnostics.

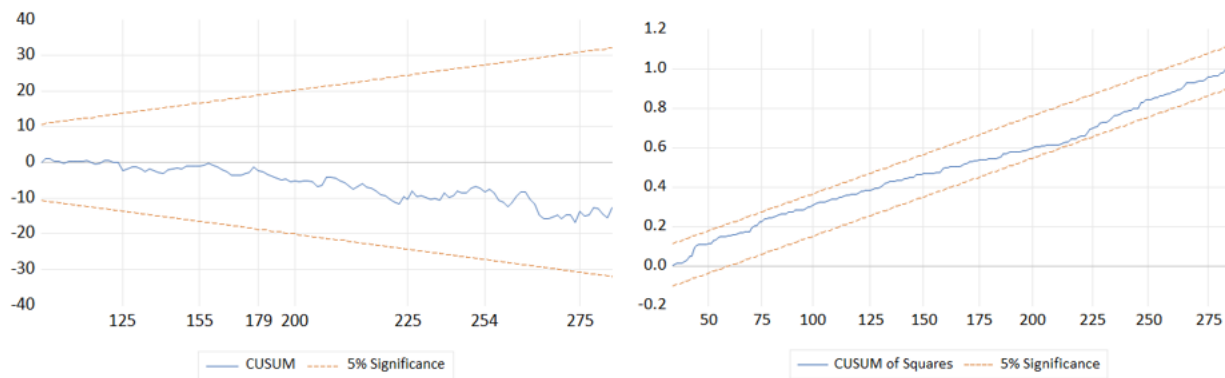


Figure 3. Graphs of model 2 stability diagnostics.

5. DISCUSSION

Our empirical results show that DF does not significantly affect FI among the countries in the sample, failing to support H1. Our finding is inconsistent with several prior studies (Al-Smadi, 2023; Bede Uzoma et al., 2020; Menza et al., 2024; Shen et al., 2021; Siddik & Kabiraj, 2019; Thatsarani & Jianguo, 2022; Umar et al., 2025) that reported a positive link. Methodological differences between the aforementioned studies and the current study may account for the inconsistent findings. In particular, the cross-country studies by Siddik and Kabiraj (2019) and Shen et al. (2021) used a large sample of countries from both developing and developed continents. With sample sizes of 189 and 101, respectively, the country-year observations were large and so the predictive power of DF to produce a positive relationship is statistically higher. Comparatively, we used a small sample size of 29 countries, which resulted in a relatively small number of country-year observations and so the predictive power of DF to produce a significantly positive relationship is statistically low. Additionally, the longitudinal nature of our study differs from the cross-sectional findings reported by Thatsarani and Jianguo (2022). Furthermore, our findings highlight the diverse contextual factors that distinguish Sub-Saharan Africa from other regions, particularly the Middle East and North Africa (MENA). This is supported by a study conducted by Al-Smadi (2023). Finally, the deviation of our findings from studies by Bede Uzoma et al. (2020), Menza et al. (2024), and Umar et al. (2025) in sub-Saharan Africa highlights differences in predictor selection, sample size, and analytical rigor. Our results suggest that, although digital finance platforms are widespread (World Bank, 2025), access alone does not ensure meaningful usage. Many individuals may open savings accounts, especially when incentives are offered; however, maintaining engagement in financial transactions requires more than just adopting digital financial technologies. In the SSA context, digital finance is not a determinant of financial inclusion, providing an answer to the first research question.

On the relationship between DF and financialization, as stated in research question two, we find that DF promotes financialization, fully supporting H2. As we noted earlier, there is a dearth of empirical studies linking DF to financialization, with only two studies appearing in the literature. These studies are Gao and Ren (2023) and Liu et al. (2023), both claiming that DF inhibits financialization, which contradicts our empirical finding. When juxtaposed, we observe methodological and contextual variations: these two studies were conducted at the firm level in the context of China, which has a digitally savvy population, while our study focuses on country-level analysis in the context of SSA, where digital penetration is relatively low. The promotion of financialization by DF supports the DOI theory, which explains how digital technologies are adopted over time within social (financial) systems, influenced by factors like trialability, observability, relative advantage, compatibility, and complexity (Rogers et al., 2014). By removing barriers related to cost and geography, DF enhances participation in the broader financial ecosystem (Omowole et al., 2024; Putrevu & Mertzanis, 2024), positively impacting personal finance behaviors and decisions (Pazarbasioglu et al., 2020; Werth et al., 2020). Digital finance (DF) is a key factor influencing financialization in SSA. Its spillover effects allow new entrants such as banks, nonbanks, and fintech firms to access

the financial market, promoting asset growth and increasing the number of financial institutions. This development benefits both providers and users of digital financial technologies.

The third research question probes the link between financialization and FI. Our finding confirms a positive link, suggesting that financialization enhances FI thereby validating H3. Earlier on, we stated that there is a paucity of research on the relationship between financialization and FI. Since our study is the first to validate this relationship, we are unable to relate this finding to past studies. However, some arguments drawn from conceptual literature reviews lend support to our positive finding. When a country's financial system grows or expands, it is capable of absorbing marginalized populations that were, hitherto, out of reach. Financial service providers and government agencies may collaborate to exchange information and share resources on how to reach these underserved populations. The results of this strategic collaboration could manifest in operational flexibility such as cost savings, product innovations, less competition, and faster service delivery (Gronbach, 2023; Sung, 2025; Udohaya, 2025). When viewed from the lens of the DOI theory, the grievances of marginalized populations do not immediately drive financial systems to consider integration. Instead, it takes time to study their socioeconomic conditions in order to custom-design financial products that meet their needs. Therefore, financialization not only has a direct effect on FI but also can play the role of a mediator between DF and FI. That is, financial service providers design or have the digital technologies; however, it is financialization that brings the technology to the doorstep of the marginalized, thereby enhancing FI.

6. CONCLUSION

In an effort to improve equitable access to financial services, this study examines the interconnectedness of DF, financialization, and FI in SSA, with financialization playing the role of a mediator. Our findings reveal a nuanced interplay among the variables. In the long run, (1) DF has no significant effect on FI; (2) DF has a significant positive effect on financialization; and (3) financialization promotes FI. These findings align with research questions one, two, and three, respectively. Furthermore, examining the direction of causality reveals a one-way causality from financialization to DF; a two-way causality from DF to FI as well as from FI to DF; and finally, a two-way causality from financialization to FI as well as from FI to financialization. Overall, our findings are robust to several diagnostics test.

Practical and policy implications arising from the study's findings are worth noting. From a practical perspective, financial service providers in SSA should bear in mind that initiating efforts to promote financial inclusion transcend beyond developing or targeting customers to use digital platforms. In light of the insignificant effect of DF on FI, financial service providers should re-strategize by shifting their focus from "rigid technology design" to committing more resources to "flexibility-oriented design" that prioritizes customer-centric data protection, ease of digital platform use, and low-cost service charges. That financialization mediates the DF–FI nexus calls for collaboration between financial service providers and the national regulatory body to enact financial liberalization policies, so that countries in SSA can fit into the global financial system. From a policy perspective, the central bank, securities and exchange commissions, and other regulators in SSA countries should launch financial literacy campaigns more frequently to promote digital FI among the populace.

The contributions of our study's findings to theory, practice, and policy notwithstanding, there are few limitations that should be pointed out. For context, our study is limited to the emerging economies of SSA countries. This means that our findings cannot be extrapolated to other emerging economies on other continents due to variations in financial market data and macroeconomic characteristics. Our findings also do not apply to the North Africa region; hence, readers should exercise caution when interpreting the findings. Methodologically, while the proxies used adequately measured the study's variables, we determine that there are other proxies that could be suitable. For example, our choice of "ATMs per 100,000 adults" as a proxy for digital finance was based on the fact that it is the most common measure adopted by previous researchers. Mobile money, which has permeated almost all

countries in SSA, could be a better proxy; however, we did not use this proxy because of data unavailability. Additionally, our choice of “commercial bank branches per 100,000 adults” was justified because it is a defining characteristic of financialization. While “ratio of financial sector value-added to GDP” could be a better proxy, this specific data is not covered by the World Bank. Finally, future research can improve upon our study by integrating certain “institutional quality” factors, such as regulatory quality and government effectiveness, as moderators to understand boundary conditions under which digital finance affects financial inclusion.

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