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The nexus among digital financial inclusion, monetary policy transmission, and economic development in Sub-Saharan Africa

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Abstract

This paper aims to examine the complex relationship between digital financial inclusion, monetary policy transmission, and economic development in 18 Sub-Saharan African countries from 2004 to 2021. The study utilizes panel data and employs a digital financial inclusion index, broad money growth, and real gross domestic product per capita as proxies for digital financial inclusion, monetary policy transmission, and economic development, respectively. The panel autoregressive distributed lag model results uncover a bi-directional causality between economic development and digital financial inclusion, emphasizing the pivotal role of digital financial inclusion in fostering economic development. Additionally, another bi-directional causality between digital financial inclusion and monetary policy transmission highlights their interdependence. Unidirectional causality from monetary policy transmission to economic development is also established. This study emphasizes the crucial role of robust measures in enhancing digital financial inclusion to avert adverse consequences, offers nuanced insights into policy dynamics, particularly regarding inflation mitigation, and enhances monetary policy effectiveness. These findings underscore the importance of policy reform, legislation, and regulatory improvements to promote digital financial inclusion by Sub-Saharan African central banks. Strengthening rural financial infrastructure is crucial for driving digital financial inclusion, sustainable economic development, and reducing regional inequalities.

Keywords: Digital financial inclusion, Sustainable economic development, Monetary policy transmission, Sub-Saharan Africa, Panel data models

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1. Introduction

The coronavirus (COVID-19) pandemic, spanning the last three years, has undoubtedly taken a significant toll on global economic progress. However, paradoxically, it has also acted as a catalyst, driving a global surge in digital financial inclusion (World Bank, 2022). As observed by Dluhopolskyi *et al.* (2023) and Tay *et al.* (2022), while the pandemic had a global negative impact on output and employment, it accelerated the rate of implementation of digital technologies such as online payment platforms, online marketing, and financial technologies (FinTech). The pivotal role of digital payments in curtailing the spread of COVID-19 during the 2020-2022 period underscores the heightened relevance of digital financial services (Dluhopolskyi *et al.*, 2023; Lagna and Ravishankar, 2021).

Remarkably, over the past decade, the global financial inclusion rate has surged from 51% to an impressive 76%, with adults in developing countries now boasting a bank or mobile money account at a rate of 71%, compared to a previous 42%. Moreover, a significant reduction in the gender gap in account ownership has been observed, dropping from 95% to 76% in developing countries (World Bank, 2022). This notable progress highlights the pervasive adoption of digital financial services globally, with more than 80 nations embracing these transformative services (UNCTAD, 2021).

Digital financial inclusion (DFI) encompasses using affordable digital tools to connect marginalized communities with an array of formal financial services tailored to their specific needs (World Bank, 2020). The impact of financial inclusion on business development cannot be overstated, as low levels of financial inclusion can hinder the establishment and growth of new enterprises, as well as the expansion of existing ones (Zogning, 2023). For Sub-Saharan Africa (SSA), where private-sector-led economic models are instrumental in providing goods, services, and employment opportunities (Zogning, 2023; Badruddin, 2017), enhancing financial inclusion is paramount.

It has been established that countries with robust financial inclusion among small- and medium-sized enterprises (SMEs) possess well-developed monetary policy transmission (MPT) mechanisms and maintain relatively stable prices for goods and services (Lyons, 2021). The proliferation of mobile money and internet banking services, often delivered by telecommunications firms in collaboration with authorized network providers, has propelled financial inclusivity in numerous SSA nations, enabling both individuals and businesses to save, transfer funds, and execute payments with ease (Chinoda and Kapingura, 2023; Odei-Appiah *et al.*, 2022).

Countries like Nigeria and Kenya have emerged as prominent FinTech hubs in Africa, with Kenya's success primarily attributed to the introduction of M-Pesa mobile phone technology in 2007 (Mbiti and Weil, 2015). M-Pesa, Africa's leading mobile money service, facilitates billions of dollars in transactions annually (M-Pesa, 2023). The Central Bank of Nigeria (CBN) has similarly embraced the mobile money scheme through two distinct models involving banks and non-banks. CBN has issued licenses to 21 mobile money operators (CBN, 2019).

The adoption of mobile money has experienced significant growth in countries such as Congo, Ghana, Benin, Togo, Cameroon, Malawi, and Zambia (African Development Bank, 2022).

However, SSA grapples with a critical issue of financial exclusion, with approximately 45% of eligible adults lacking access to either mobile money or bank accounts as of 2021 (World Bank, 2022). This pervasive financial exclusion poses considerable challenges to effective monetary policy, financial development, and overall economic development within the region (Chinoda and Kapingura, 2023). This problem is further exacerbated by insufficient infrastructure, limited SME access to finance, high unemployment rates, and low levels of financial literacy, which stifles economic development (African Development Bank, 2022). Despite the potential of FinTech-driven financial services to bridge the gap in service provision, SSA remains the most economically excluded region globally (World Bank, 2022). Additionally, high monetary policy rates in countries like Zimbabwe (150%), Ghana (29.5%), Angola (18%), and Nigeria (18%) contribute significantly to this problem (Modugu and Dempere, 2022).

Persistently low levels of DFI in SSA have substantial repercussions, hindering effective MPT and impeding regional economic development (World Bank, 2022; International Monetary Fund, 2019). Notably, the limited body of research addressing the impact of DFI on the economy has yielded disparate findings. Similarly, studies exploring the relationship between DFI and or financial inclusion and MPT have produced incongruent results (Chinoda and Kapingura, 2023; Ozili, 2023; Salisu, 2022; Takyi *et al.*, 2023; Arshad *et al.*, 2021; Saraswati *et al.*, 2020). This compelling need for clarity warrants further investigation into the intricate dynamics among these variables.

It is noted that no study has undertaken a simultaneous examination of the interconnectedness of economic development, DFI, and MPT within SSA. Therefore, this study addresses this gap by investigating the potential nexus among DFI, MPT, and economic development in SSA. The study focuses on SSA due to the region's enduring challenges of financial exclusion, deficient infrastructure, and economic development obstacles (Adegboye *et al.*, 2020). An exclusive examination in this region would provide insights into the potential of DFI to mitigate these challenges. Gaining a comprehensive understanding of the intricate dynamics between monetary policy and DFI, and their collective impact on economic development, is indispensable for policymakers and financial institutions striving to foster economic development. Therefore, the study contributes to a deeper understanding of how DFI can bolster effective MPT and foster regional economic development. This study uses panel data from 18 SSA countries from 2004 to 2021 to model the linear cointegrating effects among economic development, DFI, and MPT. Data analysis is carried out using Pedroni and Kao cointegration tests (Pedroni, 1999; Kao, 1999) and the panel autoregressive distributed lag (ARDL) model (Pesaran *et al.*, 1999; Weinhold, 1999).

This study unveiled a reciprocal negative effect between DFI and economic development variables in SSA. Monetary policy transmission positively affected economic development, while DFI and MPT significantly negatively impacted each other. This analysis underscores

the intricate interplay among DFI, monetary policy, and economic progress, emphasizing prudence's need to expand credit to avert financial crises, drawing parallels between the Indian microfinance sector and the global financial crisis. The study highlights that DFI's influence on growth relies on regional financial stability, development, and commercial banking infrastructure.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature. Section 3 outlines the research methods employed. Section 4 presents and analyses the research findings. Finally, section 5 offers concluding remarks and practical recommendations.

2. Literature review

2.1 Digital financial inclusion and economic development

The finance-growth nexus, rooted in Walter Bagehot's 1870s work (Atje, 1989), posits that an efficient financial system, as argued by Bagehot, is vital for economic growth by allocating resources effectively (Barro, 1991). Schumpeter (1911) added that by facilitating capital access, the financial sector promotes innovation, investment, and efficiency, fostering growth (King and Levine, 1993). Goldsmith (1969) extended this, demonstrating that well-developed financial systems correlate with higher economic activity (Revell, 1970). Solow's (1956) exogenous growth concept and Romer's (1990) model build on this, emphasizing investments, technology, and private sector incentives in driving growth (Chirwa and Odhiambo, 2018). The World Bank (2022) notes FinTech's role in enhancing labor productivity and contributing to regional GDP growth.

2.2 Monetary policy transmission and economic development

Adam Smith's 1776 classical economic theory, explored by Ucak (2015), emphasizes that productivity and economic growth result from labor division and available equipment. From this perspective, as Eltis (2000) noted, money acts exogenously, adjusting interest rates and economic activity without direct influence and depicting money as a veil in the economic system. By contrast, Copernicus's 1517 quantity theory ties goods and services prices directly to money supply, asserting that an increased supply diminishes buying power, leading to inflation (Volckart, 1997). Milton Friedman's monetarist school builds on this, proposing a well-managed monetary policy and sufficient money supply for economic stability (Czartoryski, 1985). Monetarists, led by Friedman, argue that a steady money supply increase promotes consistent economic growth, influencing investment and spending decisions (Friedman, 1995).

2.3 Digital financial inclusion and monetary policy transmission

Digital financial inclusion significantly influences MPT through diverse channels. Expanding financial intermediation provides broader access to formal financial services for individuals and businesses (Bodie *et al.*, 2024), facilitating more efficient allocation of financial resources (Chinoda and Kapingura, 2023). This inclusion refines transmission channels, enabling direct impacts on borrowing costs, savings rates, and aggregate demand (Bodie *et al.*, 2024; Claessens *et al.*, 2008). It enhances central banks' visibility into the financial system, providing real-

time data for informed policy decisions (Claessens *et al.*, 2008). Moreover, it contributes to financial stability by reducing informal financial activities (Bodie *et al.*, 2024; Claessens *et al.*, 2008). Factors influencing its effectiveness include technological infrastructure, regulatory environments, and financial literacy (Chinoda and Kapingura, 2023; African Development Bank, 2022).

2.4 Empirical studies

The empirical literature review provides valuable insights into DFI, economic development, and MPT relationships. Due to the lack of studies focusing on the DFI impact on monetary policy, studies that used financial inclusion will be included in the review to appreciate existing research on the link between MPT and financial inclusion. Ozturk and Ullah (2022), Ugwuanyi *et al.* (2022), and Jiang *et al.* (2022) collectively established a positive relationship between DFI and economic growth. These studies emphasize that the increased accessibility and usage of digital financial services contribute significantly to overall economic development.

Takyi *et al.* (2023) delved into the SSA context by employing the System-Generalized Method of Moments (System-GMM) estimation technique using data from 2004 to 2019 to explore the implications of financial inclusion and financial development in SSA. They revealed a dual effect where financial inclusion positively contributes to economic growth. However, simultaneous increases in financial inclusion and financial development exhibit restrictive implications for economic growth. This nuanced relationship underscores the importance of a balanced approach in policy formulation. Ugwuanyi *et al.* (2022) highlighted the continued relevance of traditional banking structures, emphasizing that, even with the advent of digital finance, neglecting traditional finance may hinder comprehensive economic development. This suggests a need for a holistic approach that considers the coexistence of digital and traditional financial systems.

Employing a panel vector error correction model (VECM) approach, Evans and Adeoye (2016) studied the relationship between financial inclusion and monetary policy effectiveness in 15 African countries from 2005 to 2014. Their findings indicate a negative relationship, emphasizing the crucial role of monetary policy decisions, particularly those related to interest rates, in shaping the trajectory of economic development. Shen *et al.* (2021) contributed a cross-country perspective, demonstrating spatial spillover effects of DFI on economic growth. The authors constructed a DFI evaluation system and employed spatial data and techniques for cross-country comparison using 105 countries. Their study suggests that the positive impact of DFI extends beyond individual countries, emphasizing regional implications that need consideration in policymaking. Fernandes *et al.* (2023) and Huong (2018) underscored the role of financial inclusion in contributing to monetary stability by reducing inflation. This implies that considerations of DFI can be crucial in crafting effective monetary policy instruments to maintain price stability.

Saraswati *et al.* (2020) assessed the effectiveness of Indonesian monetary policy using time-series data spanning from 2009-Q1 to 2018-Q1 and VECM. Their study highlighted the

impact of fintech on monetary policy effectiveness, mainly through its influence on inflation rates. This suggests that advancements in financial technology can have implications for the effectiveness of traditional monetary policy, signaling the need for adaptive policy frameworks. Investigating the impact of financial inclusion on monetary policy effectiveness in West Africa using descriptive and inferential methods, including regression and the GMM, Akanbi *et al.* (2020) stressed the importance of effective legal and regulatory frameworks to promote voluntary financial inclusion when they investigated the impact of financial inclusion on monetary policy effectiveness in West Africa from 2005 to 2018. This finding underscores the significance of policy interventions in creating an environment conducive to inclusive economic development. Evans and Adeoye (2016) and Mbutor and Uba (2013) demonstrate a significant long-term relationship between financial inclusion and monetary policy effectiveness. These studies suggest that the impact of financial inclusion on monetary policy is sustained over time, emphasizing the enduring nature of these relationships.

The reviewed empirical studies employed diverse variables to investigate the complex relationships among DFI, MPT, and economic development. Notably, indicators capturing the extent of DFI play a central role. Ozturk and Ullah (2022) used ATMs per 100,000 adults as a proxy for DFI, highlighting the significance of physical infrastructure in fostering financial inclusion. Ugwuanyi *et al.* (2022) differentiated between traditional and DFI, employing a DFI index across SSA countries. Economic development is predominantly measured through gross domestic product (GDP) and economic growth rates. Salisu (2022) utilized real GDP to assess economic growth in developing countries, emphasizing its role as a key metric. The impact of MPT mechanisms, particularly interest rates, is a common thread across studies. Evans and Adeoye (2016) and Mbutor and Uba (2013) linked financial inclusion and monetary policy effectiveness using central bank interest rates. Additionally, Chipote and Makhetha-Kosi (2014) showed that traditional monetary instruments like money supply, repo rates, and exchange rates have a role in driving economic growth in South Africa. The use of financial inclusion indices is evident in Akanbi *et al.* (2020), highlighting the importance of legal and regulatory frameworks for promoting voluntary financial inclusion in West Africa. These variables collectively offer a nuanced perspective on the multifaceted relationships within the context of SSA, contributing to a better understanding of the interplay between DFI, monetary policy, and economic development in the region.

Existing empirical studies employed diverse methods, variables, and estimation techniques to investigate the relationships among DFI, MPT, and economic development. These findings collectively contribute to a nuanced understanding of the intricate relationships among DFI, MPT, and economic development. They underscore the need for comprehensive policy frameworks that consider the coexistence of digital and traditional financial systems, the nuanced impact of monetary policy instruments, and the regional implications of financial inclusion. These insights are crucial for policymakers, researchers, and practitioners working towards inclusive economic development in SSA and beyond.

However, one key gap in the literature is a lack of studies that seek to establish the interplay between DFI, MPT, and economic development in SSA, and it is important to close this gap in knowledge. Firstly, given the unique economic landscape and challenges SSA countries face, understanding the dynamics of these interrelated factors in this context is essential for crafting targeted and effective policy interventions. Secondly, SSA is characterized by diverse economic structures, regulatory environments, and levels of financial inclusion. A tailored investigation into the relationships among DFI, MPT, and economic development in SSA would provide nuanced insights that may not directly apply to studies conducted in other regions. Moreover, as SSA grapples with persistent issues of financial exclusion, limited infrastructure, and economic development challenges, dedicated research in this region would shed light on how DFI can be leveraged to address these issues. Understanding the mechanisms through which monetary policy and DFI interact to influence economic development is crucial for policymakers and financial institutions seeking to promote sustainable and inclusive economic growth.

3. Research methods

3.1 Data

The primary objective of this empirical analysis is to examine the relationship among DFI, MPT, and economic development in SSA, using data spanning from 2004 to 2021. The study's time frame is determined by the emergence of mobile money services in SSA during the 2000s, making it a crucial period for investigation. To conduct this analysis, annual panel data was collected from reputable sources, specifically the World Bank and International Monetary Fund (IMF) websites. The study focuses on a sample of 18 SSA countries: Botswana, Benin, Congo Democratic Republic, Lesotho, Madagascar, Malawi, Mauritius, Namibia, Rwanda, Zambia, Zimbabwe, Angola, Uganda, South Africa, Nigeria, Liberia, Kenya, and Tanzania. These countries were selected based on data availability and their geographical representation, covering Southern, East, Central, and West Africa. Due to data constraints, the study considers only five key variables to fulfill its research objectives.

It is important to note that economic growth refers to the increase in a country's output of goods and services over time, typically measured by the rise in GDP. It is a quantitative concept focusing on expanding an economy's production capacity (Van den Berg, 2016). Economic growth is often associated with increased investments, technological progress, and higher productivity, leading to a larger volume of goods and services (King and Levine, 1993). On the other hand, economic development is a broader and more qualitative concept. It encompasses improvements in various aspects of people's well-being, including income distribution, education, healthcare, and overall living standards (Petrakis, 2020; Van den Berg, 2016). Economic development involves not only an increase in the quantity of goods and services but also positive changes in the quality of life for the population. It reflects a more holistic view of progress that goes beyond material wealth to consider social and human factors. In economics research, economic development is measured or proxied by per

capita GDP growth (Chinoda and Kapingura, 2023; Thaddeus *et al.*, 2020; Shen *et al.*, 2021; Petrakis, 2020) due to the qualitative nature of measuring economic development.

While studies by, for example, Jiang *et al.* (2022), Huong (2018), and Shen *et al.* (2021) used indices calculated using a mathematically complex PCA method, this study used a much simpler approach to construct a DFI index. The index is based on calculating a simple average of the three proxy variables: ATMs (per 100,000 adults), number of mobile money and internet banking transactions (per 100,000), and real interest rates for each year from 2004 to 2021. The use of a simple index for measuring DFI is also supported by Huong (2018), who applied it in their study.

Table 1 displays the summary statistics of the data for the three variables: GDP per capita growth (GDPPCG), DFI, and broad money growth (BRDMG).

Table 1. Descriptive analysis

Variable		Mean	Std. Dev.	Min	Max	Observations
GDPPCG	Overall	1.796	4.113	-18.323	19.938	N = 324
	Between		1.051	0.053	4.578	n = 18
	Within		3.984	-17.075	21.187	T = 18
DFI	Overall	22.368	16.127	-15.690	69.838	N = 322
	Between		5.422	11.902	32.990	n = 18
	Within		15.249	-17.655	66.902	T = 18
BRDMG	Overall	19.920	33.359	-54.685	485.547	N = 323
	Between		12.253	9.574	62.600	n = 18
	Within		31.148	-97.362	442.869	T = 18

Source: Authors' calculation

Table 1 displays essential statistical summaries for each study variable, including mean, standard deviation, minimum, and maximum, providing a comprehensive dataset overview. Analyzing the connection between DFI and economic development in SSA is crucial, considering the region's modest average GDP growth rate of 1.8% over the past 18 years. The notable uptrends in DFI and BRDMG by 22% and 19%, respectively, underscore the significance of unraveling this relationship.

DFI in SSA exhibits substantial variation, exemplified by Uganda's lowest DFI growth rate of -15% in 2009, By contrast to Kenya's remarkable growth of approximately 69% in 2021. Kenya's success can be attributed to the rapid expansion of M-Pesa mobile phone technology, solidifying its position as a FinTech leader in Africa. While DFI in SSA still trails behind other global regions, the data reflect significant growth potential for digital financial services to foster economic development. It is noteworthy that Zimbabwe has experienced diverse economic growth rates, from a negative GDP per capita growth rate of -18% during the 2008 global financial crisis to a remarkable high of 19.9% at certain points. These fluctuations

underscore the role of various factors, including DFI, in driving economic development. Given these observations, a comprehensive analysis is essential to comprehend the intricate relationship between DFI and economic development in SSA.

Table 2 presents the correlation matrix of the study variables, revealing weak correlations among them and minimizing concerns related to multicollinearity when performing regression analysis.

Table 2. Correlation analysis

Variables	GDPPCG	DFI	BRDMG
GDPPCG	1.000		
DFI	-0.258	1.000	
BRDMG	-0.047	-0.085	1.000

Source: Authors' calculation

The stationarity of the variables was rigorously examined using Fisher-type tests, specifically the Augmented Dickey-Fuller (ADF) and Im, Pesaran, and Shin (IPS) tests. These tests were conducted under three deterministic assumptions: constant, trend, and intercept, as well as a scenario with no deterministic components. Employing multiple tests concurrently ensures the robustness of the results. However, it is worth noting that other stationarity tests, such as Levin-Lin-Chu, Harris-Tzavalis, Hadri, and Breitung, were not applicable due to panel data being unbalanced. The null hypothesis for these stationarity tests posits that all panels contain a unit root. The outcomes of these tests are presented in Table 3.

Table 3. Panel unit root tests

	Fisher-type		Im-Pesaran-Shin		
	Constant	Trend and Intercept	Constant	Trend and Intercept	Decision
Tests in levels					
RGDPPCG	5.736***	12.504***	-3.002***	-5.358***	I(0)
DFI Index	-3.425	-1.327	4.090	0.555	-
BRDMG	21.065***	23.111***	-9.219***	-9.893***	I(0)
Tests in first differences					
RGDPPCG	-	-	-	-	
DFI Index	2.593***	1.146*	-2.727***	-1.716**	I(1)
BRDMG	-	-	-	-	

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

The stationarity analysis reveals that the variables have mixed orders of integration; specifically, GDPPCG and BRDMG are found to be stationary at levels, while DFI requires first-order differencing to achieve stationarity. All conducted tests consistently yield p-values significantly less than 1%, leading to rejecting the null hypothesis in favor of the alternative, confirming the stationary nature of GDPPCG and BRDMG. After the first differencing process, DFI is also rendered stationary. These findings endorse the suitability of applying the ARDL model for the subsequent analysis.

The most frequently occurring number of lags across all countries and variables is selected to identify the optimal lag structure for the SSA countries sample. For estimation, the suitable lag structure for GDPCCG, DFI, and BRDMG is determined to be 1, 2, and 0, respectively.

Pedroni tests with various deterministic assumptions (constant, trend, and intercept) and Kao tests were used to test for cointegration. The results are presented in Table 4.

Table 4. Kao and Pedroni co-integration tests

Dependent variable	Kao Test - ADF Statistic	Pedroni Test - ADF Statistics	
		Constant	Trend and Intercept
GDPPCG	-5.51***	-11.38***	-14.40**
DFI	4.79***	2.06**	1.41*
BRDMG	13.84***	-12.35***	-11.84***

Notes: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

The Kao and Pedroni co-integration test results provide robust evidence of co-integration among the variables, indicating a significant and enduring long-term relationship among DFI, MPT, and economic development. Consequently, the panel ARDL model is the suitable estimation technique to capture the short- and long-run dynamics among these variables.

3.2 Estimation method

The panel ARDL model (Pesaran and Smith, 1995; Pesaran *et al.*, 1999) was employed to examine the short- and long-run relationships among DFI, MPT, and economic development. This approach is advantageous for analyzing variables that exhibit different orders of integration, including I(0),I(1), or a combination of both (Pesaran and Shin, 1998). The ARDL model is inappropriate if any series has an order of integration greater than two. Unlike traditional estimation methods, the ARDL model allows for exploring variable adjustments towards both short-run and long-run equilibrium conditions.

The F-statistic was employed to establish a long-term relationship, with critical values for the upper bound I(1) and lower bound I(0) significance levels at 1%. A long-term relationship exists if the F-statistic exceeds these critical values, while no such relationship exists if it falls below them. If the F-statistic falls between the crucial values of I(0) and I(1), it is

considered inconclusive (Kapaya, 2021). According to Pesaran and Shin (1998), the equation that describes the ARDL (p, q) model is as follows:

$$Y_{it} = \sum_{j=2}^{P} \varphi_{i,j} Y_{i,t-j} + \sum_{j=1}^{q} \delta_{i,j} X_{i,t-j} + \sum_{j=0}^{r} \omega_{i,j} Z_{i,t-j} + \vartheta_i + \varepsilon_{it}, \quad (1)$$

where $t = 1,....T$ represents the time, j stands for the number of lags, $i = 1,2,...$, N is the number of countries, $X_{i,t}$ and $Z_{i,t}$ represent the vectors of independent variables, and ϑ_i is the specific fixed effect of the countries. To consider the long-run dynamics and the adjustment coefficient, equation (1) is rewritten as follows:

$$\Delta Y_{it} = \varnothing_i (Y_{i,t-1} - \theta_{i,j} X_{i,t}, Z_{i,t}) + \sum_{j=2}^{p-1} \varphi'_{i,j} \Delta Y_{i,t-j} + \sum_{j=1}^{q-1} \beta_{1i} \Delta X_{i,t-j} + \sum_{j=0}^{r-1} \beta_{2i} \Delta Z_{i,t-j} + \vartheta_i + \varepsilon_{it}, \quad (2)$$

where θ represents the long-run equilibrium relationship among Y_{it}, $X_{i,t}$ and $Z_{i,t}$, adjustment coefficient of the long-run dynamics is represented by $\varnothing_i$; $\varphi'_{i,j}$, β_{1i}, and β_{2i} indicate the short-term coefficients relating economic development to its prior performance and other variables, $X_{i,t}$ and $Y_{i,t}$. In this study, the following ARDL models are estimated as follows:

$$GDPPCG_{it} = \varnothing_i \left(GDPPCG_{i,t-1} - \theta_{1i} DFI_{i,t} - \theta_{2i} BRDMG_{i,t} \right) + \sum_{j=2}^{p-1} \varphi'_{ij} \Delta GDPPCG_{i,t-j} + \sum_{j=1}^{q-1} \beta_{1i} \Delta DFI_{i,t-j} + \sum_{j=0}^{q-1} \beta_{2i} \Delta BRDMG_{i,t-j} + \vartheta_i + \varepsilon_{it}, \quad (3)$$

$$DFI_{it} = \varnothing_i \left(DFI_{i,t-1} - \theta_{1i} GDPPCG_{i,t} - \theta_{2i} BRDMG_{i,t} \right) + \sum_{j=2}^{p-1} \varphi'_{ij} \Delta DFI_{i,t-j} + \sum_{j=1}^{q-1} \beta_{1i} \Delta GDPPCG_{i,t-j} + \sum_{j=0}^{q-1} \beta_{2i} \Delta BRDMG_{i,t-j} + \vartheta_i + \varepsilon_{it}, \quad (4)$$

$$BRDMG_{it} = \varnothing_i \left(BRDMG_{i,t-1} - \theta_{1i} GDPPCG_{i,t} - \theta_{2i} DFI_{i,t} \right) + \sum_{j=2}^{p-1} \varphi'_{ij} \Delta MPT_{i,t-j} + \sum_{j=1}^{q-1} \beta_{1i} \Delta GDPPCG_{i,t-j} + \sum_{j=0}^{q-1} \beta_{2i} \Delta DFI_{i,t-j} + \vartheta_i + \varepsilon_{it}. \quad (5)$$

Equations (3) to (5) were analyzed using three estimators: mean group (MG), pooled mean group (PMG), and dynamic fixed effect (DFE), with a Hausman test determining the robust estimator. PMG permits varying short-run coefficients and error variances across countries but assumes homogeneity in long-run slope coefficients (Zardoub and Sboui, 2020). PMG improves efficiency compared to MG estimators under the long-run slope homogeneity assumption (Pesaran *et al.*, 1999). Despite the assumption of a homogeneous long-term relationship among financial inclusion, monetary policies, and economic development in

SSA countries, local regulations and over-lending affect short-term effects. Thus, country heterogeneity is crucial in the short term.

The MG approach by Pesaran and Smith (1995) estimates separate regressions for each country, permitting heterogeneity in both long and short runs. However, accurate results require a long time series dimension (Rafindadi and Yosuf, 2013). The DFE estimator, akin to PMG, maintains similarity in slope coefficients and error variances in the long run across countries and demands uniform speed of adjustment and short-run coefficients. It includes country-specific intercepts and utilizes the cluster option for estimating intra-group correlation in standard error (Blackburne and Frank, 2007).

4. Results and discussions

The Hausman-type test is applied to choose the most preferred or robust method among the three (i.e., PMG, MG, and DFE). Table 5 shows the p-values for the tests.

Table 5. Hausman-type tests for choosing the most robust model.

Dependent variable	DFI	DPPCG	BRDMG
	PMG	PMG	PMG
MG	0.707	0.329	0.572
DFE	0.762	0.016**	0.995

Notes: ** indicates statistical significance at 5%.

Source: Authors' calculation

The null hypotheses are as follows: for a test between PMG and MG, if p-value greater than 5%, then PMG is the most efficient estimator, and if p-value lower than 5%, then MG is the efficient estimator. For tests between DFE and PMG, if p-value greater than 5%, then PMG produces the most efficient estimates, and if p-value lower than 5%, then DFE is the most efficient. The results show that when DFI and MPT are dependent variables, the PMG estimator is more efficient than the MG and DFE estimators. On the other hand, the DFE is the most efficient when economic development is the dependent variable.

4.1 Panel ARDL model estimation results

The economic development, DFI, and MPT nexus is investigated using dynamic panel ARDL data models. According to Hausman-type test findings, the pooled mean group (PMG) is largely the preferred estimation strategy for running the ARDL and ECM models on the panel data for the SSA nations. As a result, the interpretation will be centered on the PMG output, although DFE findings will also be examined when GDPPCG is a dependent variable.

Table 6 shows the impacts of each variable on the DFI under the short-run and the long-run (PMG, MG, and DFE) models for the 18 selected SSA countries.

Table 6. ARDL results with DFI as the dependent variable

All countries	PMG	MG	DFE
Variables	ΔDFI	ΔDFI	ΔDFI
Long-run			
BRDMG	-0.704***	0.492	-0.182
	(0.243)	(1.294)	(1.160)
GDPPCG	-3.949***	-3.632	-2.432*
	(0.040)	(3.264)	(1.294)
ECT	-0.129***	-0.180***	-0.093***
	(0.023)	(0.042)	(0.029)
Short-run			
D.BRDMG	-0.000	-0.006	0.030
	(0.529)	(0.051)	(0.014)
D.GDPPCG	0.526***	0.772***	0.261**
	(0.171)	(0.279)	(0.103)
Constant	7.996***	9.164***	5.194***
	(1.152)	(2.117)	(0.888)
Observations	303	303	303

Notes: Standard errors are in parentheses. Δ is the difference operator. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

Based on the Hausman test results, our primary focus will be on the findings derived from the PMG estimator. The long-run results indicate that MPT has a significantly negative impact on DFI, suggesting that a 1% increase in MPT leads to approximately a 0.7% decrease in the DFI index. This outcome aligns with prior studies by Akanbi *et al.* (2020), Huong (2018), and Evans and Adeoye (2016). This result contrasts with the findings by Fernandes *et al.* (2023) and Saraswati *et al.* (2020), who found a positive impact. Similarly, in the long run, economic development exhibits a significantly negative influence on DFI, implying that a 1% increase in economic development results in roughly a 3.95% decrease in DFI. In the short run, MPT shows an insignificant effect on DFI. By contrast, economic development positively impacts DFI, indicating that a 1% increase in economic development leads to a 0.53% increase in DFI. These short-run findings are consistent with studies conducted by Salisu (2022), Takyi *et al.* (2023), and Shen *et al.* (2021). Additionally, a statistically significant negative error correction parameter at the 1% level suggests a long-run relationship between the variables, reinforcing these estimations.

Table 7 shows the impacts of each variable on the economic development under the short-run and the long-run (PMG, MG, and DFE) models for the 18 selected SSA countries.

Table 7. ARDL results with GDPPCG as the dependent variable

All countries	PMG	MG	DFE
Variables	ΔGDPPCG	ΔGDPPCG	ΔGDPPCG
Long-run			
BRDMG	0.053**	0.006	0.004
	(0.023)	(0.041)	(0.010)
DFI	-0.056***	-0.090***	-0.082***
	(0.012)	(0.027)	(0.019)
ECT	-0.798***	-1.021***	-0.808
	(0.086)	(0.070)	(0.059)
Short-run			
D.BRDMG	-0.032*	-0.018	-0.023***
	(0.017)	(0.018)	(0.079)
D.DFI	0.040**	0.041*	0.077**
	(0.019)	(0.024)	(0.035)
Constant	1.712***	3.054***	2.668***
	(0.413)	(0.894)	(0.516)
Observations	303	303	303

Notes: Standard errors are in parentheses. Δ is the difference operator. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

As mentioned earlier, considering the Hausman test results, both the PMG and DFE estimators should be considered, but the PMG estimator presents more consistent and significant results, including a significant negative error correction mechanism (ECM) coefficient. In the long run, the results indicate that DFI has a significantly negative impact on economic development at a 1% significance level. In comparison, MPT has a positive impact at a 5% significance level. Specifically, a 1% increase in DFI leads to a 0.057% decrease in economic development, consistent with studies conducted by Oruo (2013) and Law and Singh (2014). On the other hand, a 1% increase in MPT results in a 0.054% increase in economic development. These findings align with studies by Akalpler and Duhok (2018) and Babatunde and Olasunkanmi (2023). In the short run, MPT has a less significant negative effect on economic development, while DFI positively contributes to economic development. Specifically, a 1% increase in DFI leads to a 0.04% increase in economic development, consistent with studies by Babatunde and Olasunkanmi (2023) and Chipote and Makhetha-Kosi (2014). A significant negative sign for the error correction term implies that this model converges to a long-run relationship.

Table 8 indicates the impacts of each variable on the MPT under the short-run and the long-run (PMG, MG, and DFE) models for the 18 selected SSA countries.

Table 8. ARDL results with BRDMG as the dependent variable

All countries	PMG	MG	DFE
Variables	**ΔBRDMG**	**ΔBRDMG**	**ΔBRDMG**
Long-run			
GDPPCG	0.458*	-0.311	-1.434
	(0.240)	(0.656)	(1.078)
DFI	-0.227***	0.035	-0.140
	(0.040)	(0.349)	(0.239)
ECT	-0.842***	-1.029***	-0.521***
	(0.070)	(0.065)	(0.051)
Short-run			
D.GDPPCG	-0.525	-0.410	-0.325
	(0.327)	(0.384)	(0.439)
D.DFI	-0.365	-0.362	-0.176
	(0.319)	(0.485)	(0.258)
Constant	20.227***	23.358***	13.703***
	(2.421)	(3.501)	(3.867)
Observations	303	303	303

Notes: Standard errors are in parentheses. Δ is the difference operator. * and *** indicate statistical significance at 10% and 1%, respectively.

Source: Authors' calculation

The findings show that, in the long run, economic development has a positive, less significant impact on MPT, and DFI has a negative impact on MPT at a 1% level of significance. This implies that a 1% increase in DFI leads to a 0.23% decrease in MPT, and the results are in line with studies by Huong (2018) and Lenka *et al.* (2016). In the short run, DFI and economic development have an insignificant effect on MPT. A significant negative sign for the error correction term implies that this model converges to a long-run relationship.

4.2 Hypotheses tests

The hypotheses of the study aim to find the tripartite relationships among the variables, that is, to find out if the variables have any relationship or impact on each other. Table 9 summarizes long-run causation analysis among the variables for SSA countries.

The results show a bi-directional causality between economic development and DFI, consistent with a study by Sethi and Acharya (2018). A bi-directional causality exists between DFI and MPT, supported by studies by Arshad *et al.* (2021) and Anarfo (2019). There is uni-

directional causality from MPT to economic development, consistent with studies by Akalpler and Duhok (2018) and Chipote and Makhetha-Kosi (2014). The error correction terms are again negative and significant, showing convergence in the long run.

Table 9. Summary of long-run causality

All countries		Long-Run Coefficients		
Dependent Variables	**GDPPCG**	**DFI**	**BRDMG**	**ECT**
ΔGDPPCG		-3.949**	0.458*	-1.016***
		(0.090)	(0.240)	(0.234)
Causality		Yes	No	
ΔDFI	-0.056***		-0.227***	-0.129**
	(0.012)		(0.040)	(0.023)
Causality	Yes		Yes	
ΔBRDMG	0.053**	-0.704***		-0.842***
	(0.023)	(0.243)		(0.070)
Causality	Yes	Yes		

Notes: Standard errors are in parentheses. Δ is the difference operator. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

4.3 Discussion

The findings of this study reveal a complex interplay between DFI, MPT, and economic development in SSA. In the long run, a statistically significant negative bi-directional causality exists between DFI and economic development. This suggests that as DFI increases, economic development experiences a decline, and vice versa. However, this relationship exhibits a statistically significant and positive correlation in the short run.

One of the proxy variables employed to gauge DFI is real interest rates, a metric that reflects the affordability of credit and financial services for consumers. The study indicates that rapid credit growth, a component of financial inclusion, can potentially have adverse long-term effects on economic development, echoing the cautionary stance of the World Bank (2013) regarding credit expansion without due consideration for financial stability. A stark illustration of such a scenario can be found in the 2010 crisis in India's microfinance sector, where excessive customer indebtedness resulting from fast loan growth led to detrimental consequences (Breza and Kinnan, 2021). Likewise, the subprime mortgage crisis in the United States from 2007 to 2009 was exacerbated by the overextension of credit to uncreditworthy borrowers and relaxed mortgage-underwriting rules. In the context of SSA countries, which still grapple with financial stability issues and limited financial tools, excessive credit access can impede economic development (Gourène and Mendy, 2019).

Moreover, the negative relationship between DFI and economic development might also be attributed to regional inequality, poor domestic savings, and reliance on foreign capital sources, as Gourène and Mendy (2019) posited. While DFI can facilitate economic growth, its impact is eclipsed by factors related to financial stability, development, and the role of commercial banks (Chinoda and Kapingura, 2023). These studies underscore that substantial financial development is a prerequisite for DFI to influence economic growth significantly. In regions characterized by fragile financial systems, limited financial instruments, and ineffective policies, such as SSA countries, the effect of inclusion on growth tends to be marginal. Notably, DFI in SSA countries is primarily driven by mobile money, with other financial infrastructures lagging, which contribute to the observed negative relationship between inclusion and development.

The study also reveals MPT's positive and significant impact on economic development. Higher money supply in the economy is associated with increased inflation rates, which affect not only corporate investment but also the efficiency of productive factors. As discussed by Gatawa *et al.* (2017), inflation erodes the purchasing power of both fixed-interest rate recipients and payers over time. Accordingly, inflation affects real income and can impact GDP per capita income.

Aligned with monetarist theory, this study uses broad money growth to gauge MPT impact on economic development. Monetarists argue that money supply variations affect aggregate demand and GDP growth (Friedman, 1995). The efficacy of monetary policy, posited by Fernandes *et al.* (2023) and Huong (2018), hinges on supply-side constraints and potential crowding-out effects. In Sub-Saharan Africa (SSA) and similar low-monetization contexts, augmenting the money supply is vital for stimulating growth, leading to lower interest rates and increased investment (Evans and Adeoye, 2016).

In SSA countries, inflation stems from money and supply shocks, with recent spikes linked to supply shocks and government deficits, fueled by money creation. Conversely, reducing the money supply limits banks' lending capacity, constituting a contractionary policy. With restricted lending, investment expansion falters, contracting overall output. Thus, central banks are crucial in generating inflationary pressure and transmitting effective monetary policy.

Moreover, the study uncovers a bi-directional causality between DFI and MPT. This implies that DFI and MPT exert a mutually negative and significant impact on each other. One aspect of monetary policy, namely, money supply growth, influences money demand, which, in turn, is affected by key economic variables such as investment, consumption, exports, imports, and government expenditure (Saraswati *et al.*, 2020). In SSA, the emergence of e-money, including mobile money and cash-based instruments such as credit and debit cards, has diminished the demand for and use of physical currency. Developing these digital financial tools has consequently lowered the growth rate of cash demand. By reducing the propensity to hold cash, Chinoda and Kapingura (2023) reinforced this notion by suggesting that FinTech affects the cash-to-deposit ratio and, subsequently, the money multiplier.

In keeping with the study's findings, Dluhopolskyi *et al.* (2023) emphasized the importance of a well-functioning payment system that facilitates the circulation of money supply. However, in SSA countries, digital infrastructure, such as internet connectivity, has yet to reach remote areas, hindering the effective implementation of DFI. Limited financial inclusion in these regions results in a significant portion of domestic money remaining outside the banking system, diminishing the central bank's ability to regulate MPT.

Additionally, Takyi *et al.* (2023) posited that increasing access to banking services, including bank accounts and ATMs, can have a counterintuitive effect by reducing consumer spending and impeding economic growth, leading to a decline in inflation. This phenomenon occurs because improving access to digital financial services minimizes the cash available for everyday transactions, decreasing demand for goods and services. A decrease in aggregate demand leads to lower prices for goods and services, contributing to reduced inflation. Furthermore, Arshad *et al.* (2021) suggested that broader access to financial services enhances the government's capacity to control prices effectively, enabling the interest rate channel of monetary policy to effectively influence aggregate demand after a monetary policy tightening.

5. Conclusions

This study examined the relationship between DFI, MPT, and economic development in 18 SSA countries from 2004 to 2021. Utilizing a panel ARDL modeling technique, results showed a bi-directional, long-run negative relationship between DFI and economic development in SSA.

Additionally, MPT positively impacted economic development. DFI and monetary policy had a significant negative impact on each other. While DFI can promote short-term economic growth, a negative long-term impact suggests the need for cautious expansion of credit to avoid financial crises, as seen in India's microfinance sector and the global financial crisis (Breza and Kinnan, 2021). This study's findings shed light on the complex relationship between DFI, MPT, and economic development in SSA. Moreover, the research suggests that the effectiveness of DFI on growth depends on the region's financial stability, development, and commercial banking infrastructure.

On the monetary policy front, the study underscores MPT's positive and significant impact on economic development. An increase in money supply, measured by broad money growth, is linked to higher GDP growth, which aligns with monetarist theory. However, inflation, influenced by money and supply shocks, poses challenges, emphasizing the role of central banks in managing inflationary pressures and MPT.

Furthermore, the research reveals a negative and significant bi-directional causality between DFI and MPT. The emergence of e-money and digital payment methods in SSA, such as mobile money, has reduced the demand for cash, affecting the money multiplier. Limited financial inclusion, especially in remote areas, impedes monetary policy effectiveness by keeping significant portions of domestic money outside the formal banking system.

This study has pioneered a comprehensive investigation of the interplay among DFI, MPT, and economic development in SSA, filling a critical research gap and offering insights for policymakers and financial institutions. To date, no study has simultaneously examined the interconnectedness of these variables.

This research work proposes a multifaceted approach to harnessing the potential of DFI for sustainable growth. Recommendations include promoting financial literacy, expanding digital infrastructure, fostering an enabling regulatory environment, strengthening cybersecurity measures, supporting FinTech innovation, implementing inclusive financial policies, improving monetary policy communication, enhancing data collection and analysis capabilities, and encouraging international collaboration. It emphasizes the need for continuous evaluation of DFI initiatives and capacity building in regulatory bodies and financial institutions to effectively navigate the evolving financial landscape. However, potential limitations include country selection bias and the use of proxies for DFI and MPT, which may restrict the applicability of findings to the broader SSA region.

Future research should broaden data sources, include diverse countries, and refine variable measurement to offer a comprehensive examination of DFI, MPT, and economic development in SSA. Expanding the number of countries studied and ensuring a representative sample can enhance the generalizability of findings, with attention to regional variations. Furthermore, refining variable measurement using composite indices and qualitative data can provide a more nuanced understanding of these complex concepts in SSA.

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