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Financial development, inclusion, credit supply and economic growth: an empirical study of East Africa

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ABSTRACT

This study investigates the dynamic linkages between financial sector development, financial inclusion, credit supply, and economic growth in East Africa, drawing on financial intermediation theory, endogenous growth and finance–growth nexus models. It examines how improved financial infrastructure enhances credit access and inclusion, thereby influencing long-term growth. Using annual panel data from 1990 to 2023 for Burundi, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda, composite indices for financial development, credit supply, and inclusion were constructed via Principal Component Analysis. Dynamic heterogeneous panel models, including pooled mean group, mean group, and dynamic fixed effects were applied, with robustness checks using fully modified ordinary least square, canonical cointegration regression, feasible generalized least square and Dumitrescu and Hurlin causality tests. Results show financial development significantly boosts inclusion and credit in the long run, with credit supply positively linked to growth, though high lending rates constrain expansion. Causality test reveals a long-run unidirectional link from financial development indicators to growth, with no short-run effects. Policy implications highlight deepening reforms, raising incomes, and regulating interest rates and public spending to foster inclusion and sustainable growth, while addressing regional disparities and structural barriers.

IMPACT STATEMENT

This study investigates the dynamic linkages between financial sector development, financial inclusion, credit supply, and economic growth in East Africa. Evidence from 1990–2023 shows that financial development enhances inclusion and expands credit availability, collectively supporting long-term economic growth. Causality analysis reveals a long-run unidirectional relationship from financial development, inclusion, and credit supply to economic growth, with no reverse causality. In the short run, only credit supply significantly drives growth. These findings highlight the importance of a well-functioning financial system and suggest that policies promoting financial sector reforms, wider access to credit and interest rate regulation can strengthen these linkages, fostering inclusive and sustainable growth in the region.

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1. Introduction

Financial sector development characterized by efficient institutions, deep markets, and sound regulatory frameworks, is closely linked to improved credit supply and financial inclusion, both of which are critical to sustaining long-term economic growth, particularly in developing regions. Access to formal credit facilitates productive investment and capital accumulation, while inclusive financial systems promote income stability, savings, and economic resilience among low-income populations (Jima & Makoni, 2023; Kiriga et al., 2020).

In East Africa, however, financial inclusion and credit access remain limited compared to the broader Sub-Saharan Africa average, primarily due to economic fragility, institutional inefficiencies, and market constraints (Stiftung et al., 2022). Structural bottlenecks such as high interest rates, poor banking penetration, low financial literacy, and limited credit history continue to restrict the delivery and uptake of

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credit, especially in rural and informal sectors (Atta-Aidoo et al., 2022). Cross-country evidence in East Africa suggests significant disparities in both credit availability and financial access. For instance, Kenya leads the region with a private-sector credit-to-GDP ratio of 32% as of 2023, while Ethiopia and Tanzania lag behind at 12% and 15%, respectively (Dutu et al., 2023). Sudan and Burundi exhibit severe financial exclusion and countries like Rwanda and Tanzania struggle with high non-performing loan ratios and poor credit recovery mechanisms (World Bank, 2019).

The interplay between financial sector development, financial inclusion, and credit supply is often overlooked, with most studies focusing solely on financial development's link to economic growth. In East Africa, this relationship remains underexplored despite evidence that strong financial institutions support credit growth (Rapih, 2021). While Samira and Toufik (2021) argued that financial development lowers credit barriers, findings vary by region. Al-Zu'bi and Al-Rjoub (2006) found no significant effect in Arab countries, whereas Roger et al. (2021) reported long-run benefits in Rwanda. In Sudan, only short-term impacts were observed (Ibrahim & Abdalla, 2020). These mixed results underscore the need to better understand how financial development enhances inclusion and credit supply across different contexts.

Research on the financial development-growth nexus yields mixed results, shaped by context and methodology. Radmehr et al. (2022) found stronger effects in middle-income countries, while Gogo and Wanjala (2020) reported positive outcomes in parts of East Africa. In contrast, Roger et al. (2021) found no or negative effects in Kenya and Ethiopia, emphasizing the influence of institutions, market structure, and development stage. Studies on BRICS (Biplab & Inder, 2019) and Kenya (Kiriga et al., 2020) stress the role of financial intermediaries, credit, and capital accumulation in growth.

Causality findings are also mixed: Wesiah and Onyekwere (2021) reported bidirectional causality, Mercy (2021) and Gisanabagabo (2017) supported supply-leading effects, while Ndubuisi (2017) found growth-led causality, and Kassie (2021) reported no significant effects in Burundi and Rwanda. Despite extensive work, little is known about how financial development connects with financial inclusion and credit supply in East Africa. Methodological inconsistencies further complicate results, underscoring the need for robust techniques. This study addresses these gaps using Pooled Mean Group (PMG), Mean Group (MG), and Dynamic Fixed Effect (DFE) models to capture heterogeneity and endogeneity. These dynamic heterogeneous estimators are particularly appropriate for the East African context, as they allow for cross-country heterogeneity in short-run dynamics while estimating a common long-run relationship across countries (Pesaran et al., 1999). This approach is crucial because East African countries differ in institutional quality, financial sector depth, and policy implementation and ignoring such heterogeneity could bias the results.

Against this background, this study addresses two key research questions: (1) What is the impact of financial sector development (FSD) on credit supply (CS) and financial inclusion (FI)? (2) What are the dynamic relationships among FSD, CS, FI, and economic growth in East Africa? The main objective was to examine how financial sector development affects CS and FI, and to explore the direction of causality between financial development indicators and economic growth.

This study is novel in five key ways: (1) It constructs composite indices for CS and FSD using Principal Component Analysis (PCA), capturing their multidimensional nature, unlike prior studies that rely on single indicators. The PCA is used to construct composite indices for financial development and credit supply. PCA effectively summarizes multiple related indicators into a single measure, reducing dimensionality and capturing the multi-faceted nature of these constructs. By combining PCA-based indices with dynamic heterogeneous panel estimators, the methodology ensures that both the complexity and the temporal dynamics of financial development and inclusion are adequately captured, directly serving the study's main objectives in East Africa. (2) it offers a comprehensive analysis of how FSD drives FI, expands CS, and supports economic growth in East Africa; (3) it jointly examines FI and CS as distinct but related outcomes, rather than subsuming them under overall financial development; (4) it employs heterogeneous panel methods to account for country-level differences often ignored in earlier research; and (5) it applies advanced econometric techniques fully modified ordinary least Square (FMOLS), canonical co-integration regression (CCR), and feasible generalized least square (FGLS) for robustness checks and cross-sectional dependence, which are rarely used in regional studies. In doing so, the paper aims to bridge existing gaps in the financial development literature by offering a nuanced, data-driven analysis of how financial institutions and markets shape financial access, credit allocation, and growth outcomes in the East African context.

2. Literature review

2.1. Financial inclusion and credit supply

The literature on financial sector development underscores its multifaceted impact on credit supply, financial inclusion, and economic growth. Financial inclusion broadly refers to equitable access to affordable financial services such as credit, savings, insurance, and payment systems, particularly for underserved populations (Samira & Toufik, 2021). Several theoretical strands support the importance of financial inclusion. These include public good theory, which considers financial access a universal necessity; dissatisfaction theory, linking exclusion to inequality; vulnerable group theory, which emphasizes marginalized populations; and systems theory, highlighting institutional collaboration in delivering inclusive services. These frameworks consistently position financial inclusion as a catalyst for economic empowerment, poverty reduction, and inclusive growth (Mostafa et al., 2023).

Credit supply, on the other hand, relates to the provision of financial resources through loans, advances, and trade credit by financial institutions to households and businesses. It plays a central role in stimulating private investment and macroeconomic stability (Akani & Onyema, 2017; Khan et al., 2020).

2.2. Theoretical review

Economists highlight the vital role of financial intermediaries in driving growth by facilitating investment and reducing information costs (Paul & David, 2023). Financial development enhances institutional efficiency, bridges savings and investment gaps (Dahou et al., 2009), fosters innovation (Reid, 2010), and broadens access to financial services, especially for small and medium enterprises, promoting better resource allocation (Gogo & Wanjala, 2020).

The theoretical foundation of this study rests on three core perspectives: financial intermediation theory, endogenous growth theory, and the finance–growth nexus. Financial intermediation theory posits that efficient financial institutions reduce transaction costs and information asymmetries, enabling more effective allocation of resources from savers to borrowers. Schumpeter's (1911) insights, later expanded by Levine (2005), emphasize that well-developed financial systems mobilize savings, facilitate investment, and diversify risks, thereby driving innovation and entrepreneurship.

Endogenous growth theory reinforces this by suggesting that internally driven factors such as innovation, human capital, and institutional quality sustain long-term economic growth (Romer, 1990). Within this view, financial development becomes a key enabler of productive investment in both physical and human capital, leading to higher growth trajectories. Recent scholarship increasingly highlights financial inclusion as a mediating channel: access to affordable financial services enhances household savings, smooths consumption, promotes small business formation, and increases participation in economic activity (Demirgüç-Kunt et al., 2022).

The finance–growth literature further supports this narrative. King and Levine (1993) found that countries with more developed financial systems experience faster growth, while Beck et al. (2014) argue that financial development can reduce income inequality by expanding opportunities for the poor. Financial inclusion thus emerges not only as a development outcome but also as a driver of sustainable economic transformation.

Emerging innovations in mobile banking, agency banking, and fintech have made financial services more accessible in East Africa, particularly in Kenya, Rwanda, and Uganda (International Monetary Fund (IMF), 2023; Sahay et al., 2015). These innovations have reduced geographic and institutional barriers to credit, especially for rural and low-income populations. However, weak regulatory enforcement, inadequate infrastructure, low financial literacy, and skewed access to credit still hinder the full realization of financial inclusion across the region (Allen et al., 2014; World Bank, 2024).

2.3. Empirical literature

At the global level, Demirgüç-Kunt et al. (2022) used data from the Global Findex survey to demonstrate that financial inclusion improves household savings, credit use, and overall economic participation. Their findings resonate with theoretical discussions by Samira and Toufik (2021) and Mostafa et al. (2023),

who, using systems theory, argue that inclusive financial systems can promote equitable development and reduce socioeconomic exclusion.

Recent studies have examined the role of financial development and inclusion in economic outcomes. For instance, Yadav and Goyari (2025) investigate the effects of financial development on crop productivity in Indian agriculture using an autoregressive distributive lag (ARDL) approach, showing a positive relationship between financial deepening and agricultural productivity. Another study explores the nexus between financial inclusion and financial stability in South Asian countries using a multidimensional financial inclusion index, providing evidence that improved inclusion enhances stability (Sethy & Goyari, 2022). Additionally, Sarma (2008) proposes an index of financial inclusion, which has been widely applied in empirical studies to measure the breadth and depth of inclusion across countries. These studies inform the theoretical and empirical foundation for analyzing financial development and inclusion in the context of East Africa.

Regional studies highlight various factors influencing credit supply. In Ghana, Baoko et al. (2017) found real lending rates and bank deposits negatively affect private-sector credit, while Kapaya (2023) emphasized the crowding-out effect of government borrowing. In Rwanda, Delphine et al. (2022) reported a positive impact of bank deposits and a negative effect of interest rates. Khan et al. (2020) and Kiriga et al. (2020) conducted panel regressions across African economies, including East Africa, and established that increased access to bank credit significantly contributes to economic growth. These findings support the finance-led growth hypothesis and underscore the importance of well-functioning credit markets.

In Nigeria, Akani and Onyema (2017) showed that public spending, inflation, and government revenue constrain credit supply, whereas real gross domestic product (GDP) enhances it. Similar findings in Tanzania and Ethiopia confirm that economic growth supports credit expansion, while inflation and high lending rates are deterrents (Assefa, 2014; Ndanshau & Semu, 2023). According to Baoko et al. (2017), Kapaya (2023) and Delphine et al. (2022), real interest rates, government borrowing, deposit mobilization and inflation influence these outcomes. In Tanzania and Ethiopia, evidence also highlights how macroeconomic stability, real GDP growth, and financial infrastructure affect the depth of credit markets (Assefa, 2014; Ndanshau & Semu, 2023). The study found that while inflation constrains credit supply, economic growth stimulates it, confirming the dual influence of macroeconomic stability and development momentum.

Studies focused on credit supply determinants further underscore the complexity of financial intermediation in developing economies. In Ghana, Baoko et al. (2017) show that higher real interest rates and increased deposits can reduce private sector credit, likely due to liquidity preference and risk aversion by banks. Complementing this, Delphine et al. (2022) found that bank deposits positively affect credit supply in Rwanda, whereas higher lending rates discourage borrowing.

Empirical evidence on financial inclusion also highlights its transformative potential in East Africa. Allen et al. (2014) and the World Bank (2024) reported that mobile banking significantly expands financial inclusion, especially in underserved rural areas. However, infrastructure deficits and low financial literacy remain persistent barriers. Sahay et al. (2015) and the International Monetary Fund (IMF) (2023) reinforced these findings, showing through empirical case studies and panel analysis that digital financial innovation enhances credit access and supports growth by broadening financial services to marginalized groups.

Financial inclusion and credit supply are often constrained by underdeveloped financial systems (Aghion et al., 2005). Neoclassical theory links higher savings to increased credit supply lower interest rates, and greater investment (Lindner, 2015), with discount rate changes influencing borrowing behaviour (Youngman, 1922). Access to affordable credit is critical for low-income and marginalized groups, fostering entrepreneurship, income growth, and poverty reduction (Tran et al., 2022). Finally, summary of empirical literature is shown in Table 1.

2.4. Research gaps

Although the relationship between financial development, credit supply, and economic growth has received substantial attention in the global literature, important theoretical and empirical gaps persist, especially in the context of East Africa. Theoretically, financial development, financial inclusion, and credit supply are often treated as separate domains of inquiry. Financial intermediation theories (e.g. Greenwood & Jovanovic, 1990; Gurley & Shaw, 1960) explain how financial development facilitates growth through capital allocation and risk diversification. Meanwhile, financial inclusion is typically

Table 1. Comparative summary of prior studies.

Country/region	Methodology used	Focus area	Key findings	Author(s) & year
Global	Theoretical review	Theoretical framing of financial inclusion	Financial inclusion promotes empowerment and inclusive growth.	Samira and Toufik (2021)
Global	Theoretical & conceptual analysis	Financial inclusion in systems theory	Financial services reduce exclusion for marginalized communities.	Mostafa et al. (2023)
Nigeria	ARDL Bounds Testing	Credit supply & macroeconomic variables	GDP growth increases credit; inflation & government spending reduce it.	Akani and Onyema (2017)
Various	Panel regression	Credit supply and economic growth	Bank credit significantly improves economic growth.	Khan et al. (2020); Kiriga et al. (2020)
Ghana	OLS and Error Correction Model (ECM)	Determinants of credit supply	Real interest rates and deposits reduce private sector credit.	Baoko et al. (2017)
Tanzania	Time-series econometrics	Fiscal dominance effect on private credit	Government borrowing crowds out private sector credit.	Kapaya (2023)
Rwanda	Panel regression	Bank-level credit determinants	Bank deposits increase credit; interest rates reduce it.	Delphine et al. (2022)
Ethiopia	Johansen co-integration and VECM	Credit-growth interaction	Inflation hinders credit expansion; growth stimulates credit supply.	Assefa (2014)
Tanzania	ARDL Model	Macroeconomic drivers of credit supply	Economic growth increases credit; inflation and interest rates hinder it.	Ndanshau and Semu (2023)
Global	Global Findex survey, regression analysis	Financial inclusion and inclusive growth	Financial inclusion improves savings, credit access, and overall participation.	Demirgüç-Kunt et al. (2022)
East Africa	Case studies & cross-country regression	Mobile banking & financial inclusion	Mobile finance promotes inclusion; literacy and infrastructure are key barriers.	Allen et al. (2014); World Bank (2024)
East Africa & Global	Empirical case studies; panel data analysis	Fintech & credit access	Digital innovation expands access to credit and improves growth prospects.	IMF (2023); Sahay et al. (2015)

Source: Compiled by the Authors from the literature.

approached through public good theory (Demirgüç-Kunt et al., 2018), systems theory (Mostafa et al., 2023), or the vulnerable group perspective (Samira & Toufik, 2021), focusing on equitable access and empowerment. However, there is a lack of an integrated theoretical framework that connects financial inclusion and credit supply as mutually reinforcing mechanisms of financial development and growth.

Empirically, global studies such as Sahay et al. (2015), Allen et al. (2014), and the World Bank (2024) highlight the importance of mobile banking, credit markets, and financial deepening in promoting economic growth. However, empirical research focusing specifically on East Africa remains limited. Most existing studies are either global or focused on regions like South Asia, providing limited insight into the unique institutional, economic, and policy conditions of East African countries. Consequently, the region lacks evidence on how financial development and financial inclusion jointly influence socio-economic outcomes. This study fills this gap by providing a region-specific analysis of financial development, financial inclusion, credit supply, and economic growth across seven East African countries, generating findings that are directly relevant for policymakers in the region. Country-level studies from Ethiopia (Assefa, 2014), Tanzania (Ndanshau & Semu, 2023) and Rwanda (Delphine et al., 2022) provide valuable insights but lack a regional comparative lens. Most of these studies rely on either single-country time-series data or pooled OLS methods, limiting their capacity to uncover cross-country heterogeneity or long-run dynamics.

Furthermore, a significant number of studies treat either financial inclusion or credit supply in isolation (Baoko et al., 2017; Kapaya, 2023), without considering their interactive and bidirectional effects on economic growth. The dynamic interdependence between these variables, especially within Sub-Saharan African economies experiencing rapid digital transformation and financial innovation, remains underexplored. As Khan et al. (2020) and Kiriga et al. (2020) show, credit access enhances growth, but how this

interacts with inclusion policies such as digital financial services or rural banking access needs further empirical verification.

There is also a methodological gap. Most existing empirical work relies on static regression or time-series models that fail to account for cross-sectional dependence, unobserved heterogeneity, or dynamic feedback mechanisms. Few studies have employed dynamic heterogeneous panel models such as PMG or MG to assess the long-run and short-run relationships between financial development components and growth across a large-N, small-T panel typical of East African countries. This limits the reliability of estimates and weakens the policy relevance of findings in a heterogeneous regional setting.

2.5. Conceptual framework

The framework posits financial sector development (FSD) as the key driver of financial inclusion (FI) and credit supply (CS), which in turn influence economic growth (RGDP) in East African countries. This study is based on the knowledge that the growth of the financial sector is a key component in fostering equitable economic development in developing nations. By giving people and businesses that have historically been shut out of the formal economy access to a wide range of financial services, including savings, credit, insurance, and payments, a healthy financial sector promotes financial inclusion. By improving financial intermediaries' capacity to mobilise deposits and provide loans to productive sectors, it simultaneously strengthens the credit supply.

The conceptual framework positions financial sector development as the independent variable influencing credit supply and financial inclusion, which act as key mediators. Contextual factors such as income levels, inflation, interest rates, remittances, gross deposits, and government expenditure may moderate these relationships. This framework emphasizes the interdependence of variables and the possibility of both direct and indirect causal effects from financial sector growth to economic growth. The framework is shown in Figure 1.

3. Materials and methods

The study uses secondary data from reputable sources, including the IMF, Global Financial Development Databases (GFDD), World Bank (WB), African Economic Outlook (AEO), World Governance Indicator (WGI), and World Development Indicators (WDI), all of which provide reliable data for the countries in the study.

3.1. Method of data analysis

This study adopts dynamic heterogeneous panel estimation techniques specifically the PMG, MG, and DFE estimators due to their appropriateness for datasets with a small number of cross-sectional units ($N = 7$ East African countries) and a relatively long time dimension ($T = 34$ years). These estimators, introduced by Pesaran et al. (1999), are well-suited for panels where the assumption of parameter homogeneity across countries may be too restrictive. The MG estimator allows all parameters to vary across groups, while the DFE imposes homogeneity on both long-run and short-run dynamics. The PMG estimator strikes a balance by permitting heterogeneity in the short run but constraining long-run relationships to be homogeneous across countries, making it especially useful in macroeconomic studies involving integration and cointegration.

These estimators are derived from the ARDL framework, which enables the separation of short-and long-run dynamics, a crucial feature when exploring the structural relationship between financial development and growth (Loayza & Ranciere, 2006). Moreover, the PMG and MG estimators can account for endogeneity within the panel structure, as lagged levels and differences of the regressors help correct for simultaneity bias and omitted variable bias in macro panels (Pesaran et al., 1999).

To enhance robustness, the study incorporates FMOLS and CCR methods developed by Phillips and Hansen (1990) and Park (1992), respectively. These estimators correct for serial correlation and endogeneity in cointegrated panel regressions, improving the efficiency and consistency of long-run parameter estimates. Additionally, the study uses FGLS to address cross-sectional dependence and

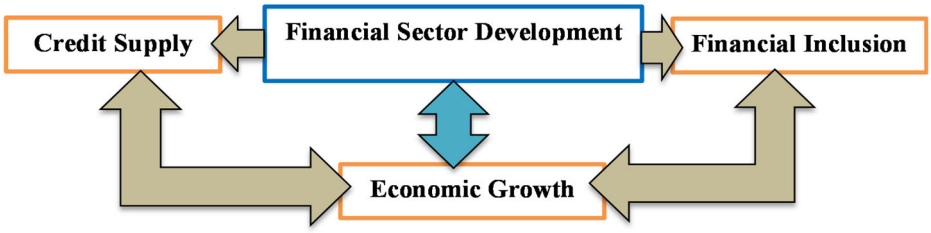

Figure 1. Conceptual framework of the study. *Source*: Compiled by the Authors from the literature.

heteroskedasticity, issues frequently encountered in panels with a small number of countries. FGLS is effective in correcting for contemporaneous correlation across units, thus yielding more efficient estimates than OLS or traditional fixed effects estimators (Beck & Katz, 1995).

Similarly, although Generalized Method of Moments (GMM) estimators especially System GMM (Blundell & Bond, 1998) are widely used in dynamic panel data analysis, they are most appropriate for panels with a large number of cross-sections (large N) and short time periods (small T). When applied to panels with small N and large T, as in this study, GMM estimators may suffer from instrument proliferation and weak instruments, which reduce the reliability of the results and may lead to over fitting (Roodman, 2009).

Given these limitations, the adoption of PMG, MG, and DFE estimators complemented by FMOLS, CCR, and FGLS represents a more robust methodological strategy for exploring the dynamic and heterogeneous nature of financial development, inclusion, and credit supply in East Africa. These methods collectively address key econometric challenges such as heterogeneity, endogeneity, serial correlation, and cross-sectional dependence, ensuring the validity and policy relevance of the empirical findings.

The choice of econometric models in this study is theoretically justified by the established relationship between financial development and inclusion in economic literature. According to the financial intermediation theory (Levine, 2005; Schumpeter, 1911), improvements in the financial system enhance access to credit, savings, and payment services, which in turn promote financial inclusion at the household and firm level. Additionally, the model incorporates both supply-side determinants (financial sector depth, institutional quality) and demand-side determinants (household income, demographic characteristics), consistent with the frameworks proposed by Demirgüç-Kunt et al. (2022) and Sarma (2008). Using a panel econometric approach allows for controlling unobserved heterogeneity across countries while accounting for temporal dynamics, thus providing both robust and policy-relevant insights into the factors driving financial inclusion in East Africa.

3.2. Model specification

3.2.1. Model 1: impact of financial sector development (FSD) on financial inclusion (FI)

FSD[1] is measured using an index constructed via PCA which includes access to finance, depth, efficiency, stability and liberalization (Damasa, 2026), while FI[2] is measured by access to finance based on International Monetary Fund (IMF) (2023) data. The PCA used is given as

$$PC_1 = a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n \tag{1}$$

Where, PC_1 is the first principal component (representing the composite index) and a_i is the loading (weight) for variable x_i corresponding to the first principal component. If the first principal component explains the largest proportion of the variance, then the index can be approximated as:

$$Index = \sum_{i=1}^{n} a_ix_i = a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n \tag{2}$$

Where, a_i are eigenvector components associated with the largest eigenvalue of the covariance (or correlation) matrix of X. After construction of the index, the PMG model for assessing the impact of financial inclusion is specified as follows:

$$Financial\ Inclusion_{it} = \alpha_i + \beta_1 Financial\ Sector\ Development_{it} + \beta_2 Control\ Variables_{it} + \varepsilon_{it} \quad (3)$$

Where, α_i represents the country-specific fixed effects (accounting for unobserved heterogeneity), $Control\ Variables_{it}$ refers to other factors that may influence financial inclusion, for country *i,* and ε_{it} is the error term for country *i* at time *t*.

The model includes several key variables: Per Capita GDP ($PCG_{i,t}$), Real Effective Exchange Rate ($REER_{i,t}$), Personal Remittance to GDP Ratio ($REMG_{i,t}$), Lending Interest Rate ($LIR_{i,t}$), Government Consumption Expenditure to GDP Ratio ($GCEG_{i,t}$), and Gross Domestic Savings to GDP Ratio ($GDSG_{i,t}$) as independent variables.

$$FI_{i,t} = f(FSD_{i,t}, PCG_{i,t}, REER_{i,t}, REMG_{i,t}, LIR_{i,t}, GCEG_{i,t}, GDSG_{i,t}) \quad (4)$$

The model of PMG is given as

$$FI_{i,t} = \sum_{j=1}^{p} \lambda_{i,j} FI_{i,t-j} + \sum_{j=1}^{q} \delta_{i,j} X_{i,t-j} + \mu_t + \varepsilon_{i,t} \quad (5)$$

The short run model of PMG is given as

$$\Delta FI_{i,t} = \theta i(FI_{i,t-1} - \lambda_i X_{i,t}) + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta FI_{i,t+j} + \sum_{j=0}^{q-1} \delta_{i,j} \Delta X_{i,t-j} + \mu t + \varepsilon it \quad (6)$$

Where i = 1 … 7 and t = 1, …, 34 and Xi is an explanatory variables. Substituting Equation (3) into Equations (5) and (6), the long- and short-run PMG estimation are given in Equation (7a) and (7b).

$$FI_{i.t} = FI_{i.t-1} + \delta_{i,1} FSD_{i,t} + \delta_{i,2} PCG_{i,t} + \delta_{i,3} REER_{i,t} + \delta_{i,4} REMG_{i,t} + \delta_{i,5} LIR_{i,t} + \delta_{i,6} lnGCEG_{i,t} + \delta_{i,7} GDSG_{i,t} + \mu_t + \varepsilon_{i,t} \quad (7a)$$

$$\Delta FI_{i.t} = \delta_0 + \delta_{i,1} \Delta FSD_{i,t} + \delta_{i,2} \Delta PCG_{i,t} + \delta_{i,3} \Delta REER_{i,t} + \delta_{i,4} \Delta REMG_{i,t} + \delta_{i,5} \Delta LIR_{i,t} + \delta_{i,6} \Delta GCEG_{i,t} + \delta_{i,7} \Delta GDSG_{i,t} + \theta_i ECT_{t-1} + \varepsilon_{i,t} \quad (7b)$$

Where Δ refers to first difference of variables; $\delta_{i,t}$ is coefficients of long-and short-run equations and θ_i is long-run speed of adjustment.

3.2.2. Model 2: impact of financial sector development (FSD) on credit supply (CS)

Following Damasa (2026), credit supply (CS) is approximated by financial depth constructed through PCA from eight variables including, deposit money bank assets to deposit money bank assets and central bank assets, deposit money banks assets to GDP ratio, domestic credit to the private sector to GDP, financial system deposit to GDP, life insurance premium volume to GDP, liquid liability to GDP, private credit by deposit money banks and other financial institutions to GDP ratio and private credit by deposit money banks to GDP ratio. The model for credit supply ($CS_{i,t}$) is specified as follows:

$$CS_{i,t} = f(FSD_{i,t}, RGDP_{i,t}, INF_{i,t}, LIR_{i,t}, GCEG_{i,t}, GDSG_{i,t}) \quad (8)$$

Where, $LIR_{i,t}$ is Lending interest rate, $RGDP_{i,t}$ is Real GDP and other variables are as described under Equation (3).

The final long run and short run PMG are given in Equation (9a) and (9b).

$$CS_{i.t} = CS_{i.t-1} + \delta_{i,1} FSD_{i,t} + \delta_{i,2} RGDP_{i,t} + \delta_{i,3} INF_{i,t} + \delta_{i,4} LIR_{i,t} + \delta_{i,5} lnGCEG_{i,t} + \delta_{i,6} GDSG_{i,t} + \mu_t + \varepsilon_{i,t} \quad (9a)$$

$$\Delta CS_{i.t} = \delta_0 + \delta_{i,1} \Delta FSD_{i,t} + \delta_{i,2} \Delta RGDP_{i,t} + {}_{i,3} INF + \delta_{i,4} \Delta LIR_{i,t} + \delta_{i,5} \Delta lnGCEG_{i,t} + \delta_{i,6} \Delta GDSG_{i,t} + \theta_i ECT_{t-1} + \varepsilon_{i,t} \quad (9b)$$

Table 2 shows the hypothesis and expected signs of all included variables in both models. Models are separated in columns with respective variables.

3.2.3. Model 3: causality between economic growth and financial development indicators

Theoretically, the causality test can yield three outcomes: unidirectional, bidirectional, or no causality. In this study, the Dumitrescu and Hurlin (2012) is used to explore causal links among FSD, FI, CS, and

RGDP. This method was chosen over traditional Granger causality tests because it accommodates heterogeneity in causal dynamics across countries, recognizing that the economic interactions between these variables may not be uniform across all economies in the region.

The key advantage of the Dumitrescu-Hurlin test in this context is its ability to deliver both individual country-level and average panel-level causality insights. Given the diverse financial systems, regulatory frameworks, and economic structures across East African countries, this test provides a more flexible and robust approach to identifying causality patterns. The causality model is specified as follows:

$$RGDP_{i,t} = a_i + \sum_{k=1}^{k} \gamma_{t,k} RGDP_{t-k} + \sum_{k=1}^{k} \beta_{i,k} X_{i,t-k} + \varepsilon_{i,t} \tag{10}$$

Where $X_{i,t}$ is FSD, CS, and FI. a_i is country specific fixed effect; $\gamma_{t,k}$ is an autoregressive coefficient; $\beta_{i,k}$ is coefficient testing the causality from X to Y; $\varepsilon_{i,t}$ is the random error term; and k is optimum number of lags. Equation (10) is reformed to Equation (11a) to Equation (11c) to estimate causality among the three variables.

$$RGDP_{i.t} = a_i + \gamma_{t,k} RGDP_{i.t-1} + \delta_{i,1} FSD_{i,t-1} + \delta_{i,2} FI_{i,t-1} + \delta_{i,3} CS_{i,t-1} + \varepsilon_{i,t} \tag{11a}$$

$$FI_{i.t} = a_i + \gamma_{t,k} FI_{i.t-1} + \delta_{i,1} FSD_{i,t-1} + \delta_{i,2} RGDP_{i,t-1} + \delta_{i,3} CS_{i,t-1} + \varepsilon_{i,t} \tag{11b}$$

$$CS_{i.t} = a_i + \gamma_{t,k} CS_{i.t-1} + \delta_{i,1} FSD_{i,t-1} + \delta_{i,2} FI_{i,t-1} + \delta_{i,3} RGDP_{i,t-1} + \varepsilon_{i,t} \tag{11c}$$

3.3. Estimation procedures

The study's estimation followed five steps: (1) testing for cross-sectional dependence (CD), homogeneity, and endogeneity; (2) conducting stationarity tests; (3) performing co-integration tests for long-run relationships; (4) estimating short and long-run models; and (5) applying FMOLS, CCR, and FGLS for robustness against CD (Moundigbaye et al., 2018).

However, in the unit root test, the second generation was employed in existence of CD with Pesaran Cross Sectionally Augmented Dickey Fuller (PESCADF) and Cross-sectionally Im-Pesaran-Shin (CIPS) (Pesaran, 2004, 2007). Using second-generation unit root tests is advantageous because they explicitly account for cross-sectional dependence among panel units, which is common in macroeconomic and financial data due to shared global or regional shocks. Unlike first-generation tests, which assume cross-section independence and risk producing biased or inconsistent results under CD, these methods incorporate common factor structures by augmenting standard unit root regressions with cross-sectional averages of lagged levels and first differences. Consequently, PESCADF and CIPS provide more robust and accurate inferences on stationarity properties when cross-sectional correlations are present. Mathematical representations were respectively given as follows:

$$\Delta yi, t = \alpha i + \beta yi_{t-1} + \gamma i\overline{y}_{t-1} + \sum_{j=0}^{\rho} \delta_{ij} \Delta y_{t-j} + \sum_{j=0}^{\rho} \lambda_{ij} \Delta \overline{y}_{t-j} + \varepsilon_{it} \tag{12}$$

Where $\overline{y}_{t-j}$ is the cross-sectional average of $y_{i,t-1}$ captures CD.

Panel co-integration tests were employed using the methods proposed by Pedroni (1999, 2004) and Westerlund (2007), while the Westurlund's co-integration test is given as

$$\Delta y_{it} = \alpha_i + \delta_i t + \gamma_i (y_{i,t-1} - \beta_i x_{i,t-1}) + \sum_{j=1}^{p} \varphi_{ij} \Delta y_{i,t-1} + \sum_{j=1}^{q} \omega_{ij} \Delta x_{i,t-j} + \varepsilon_{it} \tag{13}$$

Where γ_i representing the error correction term and Δ is first difference of the variables. Using Pedroni and Westerlund panel cointegration tests offers complementary strengths for detecting long-run relationships in panel data. Pedroni's tests allow for heterogeneous intercepts and slope coefficients across cross-sectional units, accommodating country-specific dynamics and structural differences. They also provide multiple within- and between-dimension statistics, enhancing robustness. Westerlund's test, in contrast, focuses on error-correction dynamics, directly testing whether panel members exhibit long-run equilibrium adjustment. It is more robust in the presence of CD and has better small-sample properties when common factors influence the series.

Table 2. Expected signs of variables.

Hypothesis	Expected sign	Measurement	Sources
Financial Inclusion (FI) – Dependent Variable	NA	Index of financial access to finance	IMF (2023); World Bank (2023)
H1: Financial sector development (FSD) positively affects FI.	+	PCA index: access, depth, efficiency, stability, liberalization	IMF (2023); Sahay et al. (2015)
H2: Higher per capita GDP (PCG) is associated with greater FI.	+	Real per capita GDP annual growth	Beck et al. (2014); Demirgüç-Kunt et al. (2018); IMF (2023)
H3: Appreciating real effective exchange rate (REER) reduces FI.	–	REER index	Allen et al. (2014); IMF (2023)
H4: Personal remittances (REMG) increase FI.	+	Remittances as % of GDP	Baoko et al. (2017); World Bank (2023)
H5: High lending interest rates (LIR) reduce FI and CS.	–	Lending interest rate (%)	Khan et al. (2020); Kiriga et al. (2020); World Bank (2023);
H6: Government consumption expenditure (GCEG) supports FI via social transfers/infrastructure.	+	Annual growth rate of government consumption expenditure	Allen et al. (2014); Burgess and Pande (2005)
H7: Increased domestic savings (GDSG) expand financial service outreach.	+	Annual growth rate of gross domestic savings	Khan et al. (2020); McKinnon (1973)
Credit Supply (CS) – Dependent Variable	NA	PCA index of 8 financial depth variables (see under model II)	Author's computation (PCA methodology)
H8: FSD enhances CS via improved intermediation and liquidity.	+	Financial development index (PCA from 5 indices)	Beck et al. (2014); Levine (2005)
H9: Higher economic growth (RGDP) boosts credit demand and repayment capacity.	+	Real GDP annual growth rate	Calderón and Liu (2003); King and Levine (1993)
H10: Higher inflation (INF) discourages credit provision.	– / +	Annual inflation rate (%)	Boyd et al. (2001); Hossain (2012)
H11: High lending interest rates (LIR) reduce borrowing and credit availability.	–	Lending interest rate (%)	Bernanke and Gertler (1995); Chakraborty (2012)
H12: Government consumption expenditure (GCEG) may crowd out private lending or stimulate credit demand.	+ / –	Annual growth rate of government consumption expenditure	Barro (1990); Hemming et al. (2002)
H13: Growth in gross domestic savings (GDSG) increases loanable funds for credit.	+	Annual growth rate of gross domestic savings	McKinnon (1973); Shaw (1973)

Source: Compiled by the Authors from the literature.

4. Empirical results

4.1. Descriptive statistics

4.1.1. Summary of model variables

The study begins with a descriptive analysis and correlation coefficients, using maximum and minimum values, and standard deviation to summarize the data and understand the relationships among the variables.

According to Table 3, credit supply (CS) ranged from 0.002 to 0.894, with an average of 0.373, while financial inclusion (FI) had an average index of 0.007, indicating generally low levels of inclusion across the region. Per capita GDP (PCG) varied between 19.37 USD and 2,338.6 USD. Gross domestic savings to GDP (GDSG) averaged 10.81%, and the lending interest rate (LIR) ranged from 6% to 39.11%, with a mean of 17.33%. These figures highlight significant variation in financial and macroeconomic conditions across East African countries.

4.1.2. Trend of financial development indicators and economic growth

The extent of CS varies significantly across East African countries in the sample. Kenya leads the region with the highest CS index of 0.895, followed by Burundi at 0.789. In contrast, Tanzania and Sudan have considerably lower CS indices, at 0.352 and 0.254, respectively. Rwanda (0.634), Ethiopia (0.505), and Uganda (0.4) rank after Kenya and Burundi, highlighting the diverse levels of CS within the region (see Table 4).

Uganda had the highest financial inclusion in the East African region, with an index of 0.0098, followed by Sudan (0.009), Tanzania (0.008), and Kenya (0.007). Ethiopia and Burundi both had an index of 0.007, while Rwanda ranked lowest at 0.006. These findings highlight Uganda's strong financial inclusion,

Table 3. Descriptive statistics.

variable	Obs	Mean	Std. Dev.	Min	Max
CS	238	0.373	0.216	0.002	0.894
FI	238	0.007	0.005	0.002	0.019
FSD	238	0.302	0.151	0.029	0.717
RGDP	238	4.889	5.904	−48.812	33.523
GCEG	238	12.381	5.458	0.321	32.026
INF	238	16.478	32.217	−7.224	359.092
LIR	204	17.328	5.978	6.000	39.111
REER	238	321.518	524.135	0.005	2634.321
GDSG	238	10.813	12.621	−48.51	40.380
REMG	238	1.653	1.530	0.001	7.151
PCG	238	851.088	573.195	19.370	2338.559

Source: Authors' Calculation.
Note: Except for PCG, all explanatory variables are derived from the author's earlier work. The descriptive statistics are based on the same panel dataset (1990–2023), but the present study addresses a different research question.

particularly between 2015 and 2019. Figure 2 further illustrates the trends of FSD, CS, and FI in the East African region from 1990 to 2023.

4.2. Econometric results

4.2.1. Preliminary tests

4.2.1.1. Cross-sectional dependence (CD) test. The study employed the Pesaran (2007) scaled LM test to check for CD in the panel models. Results confirmed CD in Model I (FI), while Model II (CS) showed no CD. Due to the limitations of the Breusch-Pagan LM test, the Pesaran test was used, as it is robust to heteroscedasticity and CD, especially when ($T > N$) (see Table 5).

4.2.1.2. Homogeneity and endogeneity tests. Homogeneity tests confirmed slope heterogeneity, justifying the use of the Fully PMG model for short-run analysis. Additionally, Durbin and Wu-Hausman tests indicated no endogeneity issues, supporting the model's validity and reliability. The Pesaran and Yamagata (2008) slope homogeneity test was chosen because it is well-suited for panels with small cross-sections and long time periods, as in this study ($N = 7$, $T = 34$). It improves upon earlier tests by allowing for nonstationarity and CD. The Durbin and Wu-Hausman tests were selected for checking endogeneity due to their simplicity and robustness in dynamic panel settings, avoiding the complexities and instrument sensitivity of GMM-based methods, which are less reliable in small samples (see Table 6).

4.2.1.3. Panel unit root test. Due to existence of CD, the study uses second-generation unit root tests, specifically the Cross-Sectional Augmented Dickey-Fuller (CADF) and CIPS Pesaran (2004, 2007) tests, as recommended by Zhang et al. (2020). Results show that most variables are stationary at first difference, except RGDP, INF, and FI, which are stationary at both levels and first differences (see Table 7). This pattern aligns with the findings reported in Damasa (2026).

4.2.1.4. Co-integration test. Second-generation unit root tests confirm all variables are stationary at first difference. Despite mixed Pedroni results, the significant Westerlund test confirms a long-run relationship among the variables in Model I. Similarly, the cointegration result of the second model indicates that the model exhibits a long-run relationship (see Table 8).

4.2.2. Impact of financial sector development (FSD) on financial inclusion (FI) and credit supply (CS)

4.2.2.1. multicollinearity test. The Variance Inflation Factor (VIF) results for both models indicate no serious multicollinearity issues. All VIF values are well below the commonly accepted threshold of 5, with mean VIFs of 1.655 and 1.565, respectively (see Table 9).

4.2.2.2. Regression result of MG, PMG, and DFE. Table 10 presents the MG, DFE and PMG model results on FI, revealing varied impacts. In the MG model, no long-run variables were significant, but in the short run, REER and GDSG negatively influenced FI. The DFE model showed that FSD positively

Table 4. Trends of FSD, FI, CS and RGDP in East Africa (1990–2023).

Financial development indicators/year	1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019	2020–2023
FSD	0.211	0.219	0.268	0.306	0.339	0.375	0.417
FI	0.003	0.003	0.003	0.005	0.010	0.011	0.006
CS	0.245	0.261	0.330	0.387	0.425	0.468	0.526
RGDP	0.609	0.659	0.662	0.677	0.659	0.659	0.643

Source: Compiled from data used in the study.

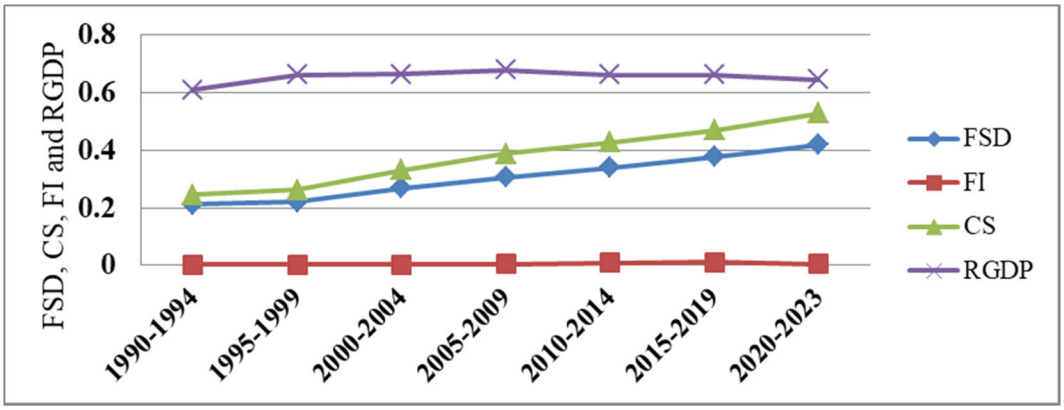

Figure 2. Trends of FSD, FI, CS and RGDP in East Africa (1990–2023). *Source*: Compiled from data used in the study.

Table 5. Cross-sectional dependence (CD) test result.

Pesaran (2007) scaled LM test		
Models/Test	CD	*P*-value
Model I(FI)	5.019	0.000***
Model II(CS)	0.387	0.698

Source: Authors' Calculation.

affected FI in the long run, while REMG, GCEG, and LIR had negative effects. The PMG model indicated that FSD, REER, and PCG had positive long-run effects, whereas GCEG, GDSG, and REMG had negative impacts. In the short run, REER had a negative effect, and the error correction term (ECT) was significant across models, confirming long-run adjustment. The MG model exhibited the fastest speed of adjustment, followed by the PMG with more significant variables. These results deepen understanding of the drivers of FI in East Africa.

In the Model II of MG estimate, FSD significantly boosts CS in both the long and short run, while LIR has a negative short-run effect. RGDP negatively impacts CS in the short run. The DFE model also confirms FSD's positive long-run influence and GCEG's negative effect, with LIR again negatively affecting CS in the short run. The ECT is significant at the 1% level in both MG and DFE models, indicating persistent long-run disequilibrium.

In contrast, the PMG model shows FSD, RGDP, INF, GDSG and GCEG all positively affect CS in the long run, while LIR exerts a negative impact. Short-run results reveal FSD's positive effect and RGDP and GDSG's negative effects on CS. The ECT in the PMG model is insignificant, suggesting no long-run disequilibrium, consistent with Omoke (2010). Table 11 summarizes the estimation techniques and corresponding diagnostic tests undertaken in the study to ensure the robustness and validity of the results.

4.2.2.3. Robustness check: FMOLS, CCR and FGLS. For robustness, FMOLS and CCR long-run models were used, with FMOLS correcting for CD. Results closely matched the PMG model, confirming consistency. FMOLS showed FSD, PCG, and REMG positively impacted FI, while REER and GCEG had negative effects. REMG's mixed impact aligned with Rehman and Hysa (2021). FGLS further addressed CD, enhancing estimate reliability for panels with more time periods than cross-sections. The close alignment of FMOLS and FGLS results with those of the PMG model strengthens the reliability and robustness of the study's findings (see Table 12).

Table 6. Homogeneity and endogeneity tests.

		Homogeneity test				Endogeneity test			
		Pesaran and Yamagata (2008)		Blomquist and Westerlund (2013)		Durbin (score)		Wu-Hausman	
Models		Delta	P-value	Delta	P-value	X^2 (1)	P-value	F(1, 228)	P-value
Model I (FI)		8.292	0.000	2.045	0.041	3.805	0.051	3.737	0.054
	Adj.	9.670	0.000	2.385	0.017				
Model II (CS)		7.898	0.000	2.089	0.037	0.308	0.578	0.299	0.585
	Adj.	9.032	0.000	2.389	0.017				

Source: Authors' Calculation.

Table 7. Results of panel unit root test.

	PESCADF			CIPS
Variables	t-bar	Zt-bar	*P*-value	CIPS- Stat.
FSD I(0)	−2.080	−0.846	0.199	−2.193
FSD I(1)	−4.271	−7.010	0.000***	−5.096***
RGDP I(0)	−3.600	−5.122	0.000***	−4.131***
RGDP I(1)	−5.553	−10.621	0.000***	−6.142***
GCEG I(0)	−1.809	−0.082	0.467	−1.580
GCEG I(1)	−4.621	−7.995	0.000***	−5.141***
INF I(0)	−2.498	−2.020	0.022**	−3.084***
INF I(1)	−5.966	−11.782	0.000***	−5.899***
LIR I(0)	−1.683	0.273	0.608	−1.448
LIR I(1)	−3.624	−5.190	0.000***	−4.030***
REER I(0)	−2.052	−0.767	0.222	−1.338
REER I(1)	−3.867	−5.875	0.000***	−4.362***
GDSG I(0)	−2.243	−1.304	0.096	−2.116
GDSG I(1)	−4.865	−8.684	0.000***	−5.608***
REMG I(0)	−2.014	−0.659	0.255	−1.743
REMG I(1)	−3.926	−6.041	0.000***	−4.869***
PCG I(0)	−2.080	−0.845	0.199	−1.693
PCG I(1)	−2.803	−2.880	0.002***	−3.312***
CS I(0)	−2.263	−1.359	0.087*	−2.286
CS I(1)	−4.139	−6.641	0.000***	−5.035***
FI I(0)	−2.945	−3.279	0.001***	−2.968***
FI I(1)	−5.116	−9.389	0.000***	−5.994***

Source: Authors' Calculation.

Note: Some variables in Table 7, including FSD, RGDP, GCEG, INF, LIR, REER, GDSG and REMG, were also reported in earlier work by the author over the same panel period under a different objective. However, the present study investigates distinct research questions and focuses on different aspects of financial and macroeconomic dynamics.

Table 8. Co-integration test result.

Co-integration tests	Statistics	Model I (FI)	Model II (CS)
Pedroni (1999)	Modified Phillips-Perron t	2.581(0.005)**	1.039(0.149)
	Phillips-Perron t	−0.011(0.495)	−2.870 (0.002)***
	Augmented Dickey-Fuller t	−0.287(0.386)	−2.689(0.004)***
Westerlund (2007)	Variance ratio	1.9609(0.025)**	3.2134(0.000)***

Source: Authors' Calculation.

Table 9. Multicollinearity test result.

Model I (FI)			Model II (CS)		
Variables	VIF	1/vIF	Variables	VIF	1/vIF
GCEG	2.547	0.393	GCEG	2.358	0.424
PCG	1.862	0.537	GDSG	1.855	0.539
GDSG	1.754	0.570	FDS	1.457	0.686
FDS	1.603	0.624	INF	1.336	0.748
LIR	1.433	0.698	LIR	1.206	0.829
REER	1.238	0.808	RGDP	1.178	0.849
REMG	1.150	0.870	-	-	-
Mean VIF	**1.655**	-	**Mean VIF**	**1.565**	-

Source: Authors' Calculation.

Table 10. Regression result of MG, PMG, and DFE.

	Model I DV(FI)			Model II DV(CS)		
Variables	MG	PMG	DFE	MG	PMG	DEF
Long Run						
FSD	0.098(0.171)	0.031(0.000)***	0.025(0.047)**	1.53(0.000)***	1.238(0.000)***	1.42(0.000)***
RGDP[1]	–	–	–	0.216(0.560)	0.349(0.000)***	0.024(0.853)
PCG [2]	−0.082(0.577)	0.009 (0.014)**	0.004(0.720)	–	–	–
GCEG	−0.066(0.490)	−0.011(0.000)***	−0.017(0.096)*	−0.158(0.287)	0.038(0.048)**	−0.179(0.046)**
INF[1]	–	–	–	0.574(0.436)	0.417(0.002)***	−0.007(0.942)
LIR	0.051(0.165)	−0.001(0.396)	−0.018(0.075)*	−0.093(0.072)*	−0.028(0.044)**	0.062(0.252)
REER [2]	−0.134(0.534)	0.006(0.000)***	−0.010(0.356)	–	–	–
GDSG	0.080(0.320)	−0.006(0.036)***	0.019(0.158)	−0.191(0.133)	0.055(0.013)**	−0.079(0.360)
REMG [2]	−0.427(0.394)	−0.006(0.042)**	−0.023(0.040)**	–	–	–
Short Run						
ECT	−0.417(0.002)***	−0.224(0.036)**	−0.108(0.002)***	−0.40(0.002)***	−0.193(0.189)	−0.12(0.004)***
D.FSD	0.003(0.599)	−0.002(0.588)	0.000(0.862)	0.91(0.000)***	1.240(0.000)***	1.36(0.000)***
D.RGDP[1]	–	–	–	−0.070(0.023)**	−0.062(0.031)**	−0.004(0.676)
D.PCG [2]	−0.016(0.354)	0.001(0.910)	−0.002(0.635)	–	–	–
D.GCEG	0.002(0.642)	−0.001(0.603)	−0.001(0.338)	0.016(0.576)	0.003(0.839)	0.019(0.130)
D.INF[1]	–	–	–	−0.019(0.571)	0.010(0.746)	−0.002(0.894)
D.LIR	0.005(0.486)	0.003(0.434)	−0.001(0.589)	−0.022(0.459)	−0.032(0.004)***	−0.023(0.036)**
D.REER [2]	−0.061(0.038)**	−0.019(0.053)*	0.002(0.473)	–	–	–
D.GDSG	−0.004(0.066)*	0.000(0.999)	−0.001(0.316)	−0.008(0.684)	−0.038(0.015)**	−0.000(1.000)
D.REMG[2]	0.017(0.510)	0.014(0.416)	−0.000(0.964)	–	–	–
CONST	0.001(0.860)	0.001(0.012)**	0.000(0.905)	−0.070(0.204)	−0.059(0.210)	0.003(0.797)

Source: Authors' Calculation.
Note: ***, **, and * refer to significant at 1%, 5%, and 10% level of significance. The numbers in the parenthesis are probability values. Variables asterisk with ([1]) are not included in the first model whereas those asterisk with ([2]) are not included in the second model. Based on the Hausman test, the PMG model was selected as the preferred approach, though MG and DFE results were also reported for comparison. For the second model, the Hausman test result indicates that the choice among the three methods is inconclusive. As a result, the study reports the outputs for all three approaches.

Table 11. Summary of all estimation and diagnostic procedures.

Test/procedure	Purpose	Outcome/result
Cross-sectional Dependence (Pesaran CD)	Test for cross-country dependence	Significant for some variables
Durbin and Wu-Hausman	Endogeneity test	Models have no endogeneity issue
Pesaran and Yamagata (2008)	Homogeneity test	The models show heterogeneity
Unit Root Test (CIPS, CADF)	Check stationarity of panel variables	All variables stationary at first difference
Cointegration Test (Pedroni, Westerlund)	Verify long-run relationship	Long-run relationship confirmed
Estimation (PMG, MG, DFE)	Analyze short- and long-run dynamics	PMG selected based on Hausman test
Robustness Check (FMOLS, CCR, FGLS)	Confirm reliability of results	Results consistent across methods

Source: Compiled by the Authors.

4.2.3. Causality between economic growth and financial sector development indicators

This study also explored the causal relationships between financial sector development indicators and economic growth in East Africa, examining both short and long-run dynamics. In this study, the Dumitrescu and Hurlin (2012) heterogeneous panel causality test was employed to examine the direction and nature of causal relationships among financial development; financial inclusion, credit supply, and economic growth across East African countries (see Table 13).

The Dumitrescu and Hurlin (2012) causality test results reveal that FI, CS, and the FSD each have a unidirectional causal impact on RGDP in the long run; emphasizing that financial sector development drives economic growth. Additionally, a bidirectional long-run causality exists between credit supply and economic growth, suggesting mutual reinforcement, as seen in the positive effect of RGDP on CS (Tables 7 and 8). Furthermore, unidirectional causality runs from FSD to FI and from CS to FI. In the short run, the only significant causal relationship is bidirectional between FSD and CS, highlighting their dynamic interdependence.

4.3. Discussion of the results

The first model explores the impact of FSD on FI in East Africa. The PMG model indicates that a 1% increase in FSD leads to a 0.03% rise in FI in the long run, highlighting financial development's role in improving access to financial services. Per capita GDP (PCG) also positively influences FI, with a 1% increase in PCG corresponding to a 0.009 percentage point increase in FI, reinforcing the link between

Table 12. FMOLS, CCR and FGLS.

	Model I			Model II		
Variables	FMOLS	CCR	FGLS	FMOLS	CCR	FGLS
FSD	0.01(10.27)***	0.01(14.28)***	0.023(16.89)***	1.40(267.90)***	1.40(209.02)***	1.479(118.4)***
RGDP[1]	–	–	–	0.02(5.88)***	0.02(3.88)***	0.052(2.4)**
PCG[2]	0.03(22.98)***	0.03(28.58)***	0.005(4.90)***	–	–	–
GCEG	−0.01(−6.76)***	−0.01(−7.79)***	−0.012(−6.01)***	−0.00(3.63)***	0.00(3.52)***	−0.09(−6.75)***
INF[1]	–	–	–	0.11(7.28)***	0.11(5.50)***	−0.014(−1.71)*
LIR	0.00(-)	0.00(-)	−0.001(−0.60)	0.00(-)	0.00(-)	−0.002(−0.36)
REER[2]	−0.02(1.92)**	−0.02(−0.84)	0.006(7.02)***	–	–	–
GDSG	0.00(−7.83)***	0.00(−9.81)***	−0.009(−5.84)***	−0.04(−2.03)***	−0.04(−0.98)	0.003(0.20)
REMG[2]	0.04(12.84)***	0.05(18.01)***	0.000(−0.05)	–	–	–
Const.	–	–	0.009(6.30)***	–	–	−0.067(−4.37)***

Source: Authors' Calculation.
Note: *** and ** refer to significant at 1% and 5% level of significance. The numbers in parenthesis are t-values.

Table 13. Long- and short-run causality test result.

Long run causality					
Hypothesises	W-bar	Z-bar	*P*-value	Z-bar tilde	*P*-value
CS does not Granger-cause RGDP	2.381	2.584	0.009***	2.165	0.030**
RGDP does not Granger-cause CS	1.902	1.687	0.091*	1.373	0.169
FI does not Granger-cause RGDP	3.469	4.620	0.000***	3.965	0.000***
RGDP does not Granger-cause FI	1.595	1.114	0.265	0.866	0.386
FSD does not Granger-cause RGDP	2.531	2.864	0.004***	2.413	0.015**
RGDP does not Granger-cause FSD	1.381	0.714	0.475	0.513	0.607
CS does not Granger-cause FSD	9.939	16.724	0.000***	14.662	0.000***
FSD does not Granger-cause CS	9.493	15.890	0.000***	13.924	0.000***
FI does not Granger-cause FSD	1.473	0.885	0.375	0.664	0.506
FSD does not Granger-cause FI	2.798	3.365	0.000***	2.855	0.004***
FI does not Granger-cause CS	1.508	0.951	0.341	0.722	0.470
CS does not Granger-cause FI	2.939	3.627	0.000***	3.087	0.002***
Short Run Causality					
D.CS does not Granger-cause D.RGDP	1.463	0.867	0.385	0.648	0.516
D.RGDP does not Granger-cause D.CS.	1.486	0.910	0.362	0.686	0.492
D.FI does not Granger-cause D.RGDP	0.399	−1.122	0.261	−1.110	0.266
D.RGDP does not Granger-cause D.FI	0.544	−0.852	0.394	−0.871	0.383
D.FSD does not Granger-cause D.RGDP	1.132	0.247	0.804	0.100	0.920
D.RGDP does not Granger-cause D.FSD	1.030	0.057	0.954	−0.067	0.946
D.CS does not Granger-cause D.FSD	2.387	2.595	0.009***	2.175	0.029**
D.FSD does not Granger-cause D.CS	2.447	2.708	0.006***	2.275	0.022**
D.FI does not Granger-cause D.FSD	1.141	0.265	0.790	0.116	0.907
D.FSD does not Granger-cause D.FI	1.663	1.240	0.214	0.978	0.327
D.FI does not Granger-cause D.CS	1.039	0.073	0.941	−0.053	0.957
D.CS does not Granger-cause D.FI	1.718	1.343	0.179	1.069	0.285

Source: Authors' Calculation.
Note: ***, **, and * refer to significant at 1%, 5%, and 10% level of significance.

economic growth and FI, which is in line with finding of Assefa (2014), particularly for Ethiopia. These results occur because financial development strengthens the institutional capacity of banks and financial intermediaries, enabling them to expand outreach, reduce intermediation costs, and introduce diversified products tailored to underserved populations. Improved financial depth and efficiency also enhance the ability of financial institutions to manage risk, which encourages them to extend services to rural households and small firms that were previously excluded.

From a theoretical perspective, the positive relationship between FSD and FI aligns with the supply-leading hypothesis, which argues that a well-functioning financial system stimulates greater participation in formal finance by increasing service availability, reducing barriers to entry, and lowering information asymmetries. As financial markets deepen, transaction costs fall and digital infrastructures such as mobile money networks—become more efficient, thereby facilitating inclusion.

The results also reflect country-specific dynamics within East Africa. In Kenya, for example, innovations like M-Pesa have expanded digital financial access as financial institutions modernize their systems. In Rwanda and Uganda, policy-driven financial reforms and agency banking have improved outreach, particularly in rural areas. Ethiopia's rapid expansion of mobile banking and agent networks despite a relatively closed financial sector illustrates how institutional reforms and financial development jointly lift

inclusion. Thus, the estimated long-run elasticity captures not just financial depth, but the cumulative effects of regulatory reforms, technological adoption, and market competition across the region.

The positive impact of PCG on FI further reflects how rising income levels increase individuals' ability to maintain bank accounts, use credit, and adopt savings products. Higher household income reduces liquidity constraints and encourages engagement with the formal financial system, which is consistent with economic theories linking income growth to the demand for secure and efficient financial services. In lower-income countries such as Ethiopia, Tanzania, and Burundi, improvements in income levels significantly boost the uptake of basic financial services, explaining the strong empirical relationship observed.

The Real Effective Exchange Rate (REER) has a positive long-run effect on FI (0.006%) but a negative short-run effect, with a 1% increase leading to a 0.02% decline in FI. This short-run decline is consistent with Delphine et al. (2022), who argue that currency appreciation or volatility can reduce households' purchasing power, increase the cost of imported financial products and technology, and weaken financial conditions, thereby limiting short-term access to financial services. In the long run, however, a stable and competitive REER can support export-led growth, increase national income, and enhance financial resources available for banking and credit, explaining the observed positive long-run effect.

Remittance inflows (REMG) also negatively impact FI, likely because a substantial portion of remittances in East Africa is allocated to immediate household consumption and basic needs rather than deposited in formal financial institutions. This reduces the liquidity available to banks for lending and investment, constraining the expansion of financial inclusion. In countries like Ethiopia and Uganda, while remittances constitute a significant income source, their usage patterns limit their potential to promote sustained financial engagement.

Similarly, government consumption expenditure (GCEG) negatively affects FI, which may reflect a crowding-out effect: higher public spending can absorb financial and fiscal resources, limiting private sector access to credit and discouraging banks from extending financial services. In East African contexts where public spending is substantial relative to GDP such as in Kenya and Tanzania, this effect can temporarily suppress financial inclusion, especially among small firms and households dependent on private credit.

From a theoretical perspective, these findings align with both the demand-side and supply-side constraints of financial inclusion. Exchange rate volatility and macroeconomic policies affect households' demand for financial services, while remittance utilization and government spending shape the supply of available credit.

Country-specific effects emerge in the heterogeneous PMG model. For example, REER negatively impacts FI in Burundi but has a positive effect in Tanzania and Uganda, reflecting differences in exchange rate stability, trade exposure, and macroeconomic conditions across countries. These variations indicate that while currency movements may restrict access to financial services in some contexts, they can simultaneously facilitate financial inclusion in countries with stronger export sectors or better-managed monetary policies.

Remittances also exhibit heterogeneous effects: they boost FI in Burundi but hinder it in Uganda, potentially due to differences in the extent to which remittances are deposited in formal financial institutions versus used for consumption. This highlights how country-specific financial infrastructure and household behavior shape the effectiveness of remittance inflows in promoting inclusion.

Gross domestic savings (GDSG) negatively impact FI in Ethiopia and Uganda, suggesting that when households rely more on personal savings, demand for formal financial services may decline. Conversely, in Rwanda, the negative effect of government consumption expenditure (GCEG) on FI reflects the crowding-out effect of higher public spending, which can absorb financial resources that would otherwise support private-sector access to financial services.

The second model evaluates FSD's impact on credit supply (CS) in East Africa. The MG model indicates that a 1% increase in FSD raises CS by 1.53% in the long run and 0.91% in the short run, demonstrating a stronger long-term effect of financial development on credit availability. Similarly, the PMG and DFE models confirm this positive relationship, with FSD increasing CS by 1.24% and 1.42%, respectively, in the long run. These results align with the financial intermediation theory, which posits that stronger financial systems facilitate resource allocation and credit provision, supporting economic growth.

Government consumption expenditure (GCEG) shows contrasting effects: a 0.38% increase in CS under the PMG model, but a negative effect of –0.18% in the DFE model, reflecting methodological differences and varying country responses to public spending. GDSG positively influences CS in the long run under the PMG model (0.06%) but shows a negative short-run impact, likely due to temporary liquidity constraints that limit lending capacity. Inflation exhibits a positive long-run effect on CS (0.44%), consistent with the notion that moderate inflation can expand bank lending via higher interest margins.

Lending interest rates (LIR) consistently reduce CS in both the short and long term 0.093% in the PMG model and 0.028% in the DFE model indicating the inhibitory effect of higher borrowing costs, consistent with empirical evidence from Tanzania (Ndanshau & Semu, 2023). These results underscore FSD's pivotal role in expanding credit supply, while also illustrating that macroeconomic indicators interact differently across countries and models, reflecting diverse financial and institutional environments.

In the heterogeneous short-run PMG model, FSD generally boosts CS across East African countries, except in Tanzania, likely due to structural or policy constraints limiting the immediate translation of financial development into credit expansion. RGDP shows mixed effects, negatively influencing CS in Burundi, Kenya, and Tanzania but positively in Rwanda, highlighting how growth trajectories and institutional frameworks affect credit demand and supply differently across countries. LIR reduces CS in Ethiopia, Kenya, and Uganda, with no significant effect in Tanzania. GDSG negatively affects CS in Sudan and Tanzania, likely due to insufficient household savings limiting bank lending capacity. Interestingly, inflation positively influences CS in Uganda, potentially because higher inflation enhances lending returns, motivating banks to extend more credit.

Although the panel-level estimates provide a regional overview, country-level experiences show meaningful variations. For example, Uganda has implemented extensive mobile financial services reforms, resulting in rapid improvements in financial inclusion compared to other member states. Kenya's M-Pesa ecosystem similarly illustrates how digital finance can accelerate inclusion and support economic outcomes, whereas countries such as Burundi and Sudan have experienced slower progress due to institutional and macroeconomic constraints. These policy differences help to contextualize the aggregate results and demonstrate the heterogeneity across the region.

The third model examines the causal relationships between economic growth and financial development indicators using the Dumitrescu and Hurlin (2012) panel causality test. The results indicate long-run unidirectional causality from financial development indicators, particularly FSD and FI to economic growth, consistent with empirical evidence from Kenya and Rwanda (Gisanabagabo, 2017; Mercy, 2021), but contrasting with Wesiah and Onyekwere (2021), who reported bidirectional causality in other contexts.

Financial inclusion (FI) is found to promote economic growth, suggesting that increased access to formal financial services enhances investment, consumption, and productive activities across households and firms. CS and growth demonstrate bidirectional causality, indicating a reinforcing feedback loop whereby higher credit availability stimulates growth, which in turn increases demand for credit. FSD also exerts a causal effect on growth, supporting the theoretical perspective from financial intermediation theory that well-developed financial systems facilitate efficient resource allocation and economic expansion.

Additionally, the analysis reveals long-run bidirectional causality between CS and FSD, highlighting those improvements in credit supply can enhance financial development, while stronger financial systems enable greater credit provision. Unidirectional causality is observed from FSD to FI and from CS to FI, underscoring that financial development and credit provision are key drivers of inclusion, which subsequently supports economic growth. In the short run, only the CS → FSD relationship is statistically significant, implying that some effects of financial development and inclusion on growth take time to materialize, reflecting structural and institutional constraints in the region.

5. Concluding remarks

This study finds that financial sector development (FSD) positively affects both financial inclusion (FI) and credit supply (CS) in East Africa over the long and short term, highlighting the importance of a well-functioning financial system in promoting economic growth. While per capita GDP (PCG) and the

real effective exchange rate (REER) support FI, factors such as government consumption expenditure (GCEG), gross domestic savings (GDSG), and remittance inflows (REMG) negatively affect FI in the long run. For CS, FSD, real GDP (RGDP), GCEG, GDSG, and inflation have positive effects, whereas high lending interest rates (LIR) reduce CS, particularly in the short run. Overall, FSD consistently promotes CS, but other factors show country-specific variations, reflecting the diverse financial and institutional environments across East Africa.

Based on these findings, governments are encouraged to prioritize financial sector development by implementing regulatory reforms, promoting digital finance adoption, and improving infrastructure to expand access in rural and underserved areas. Policies should also target credit access for small-scale farmers, microenterprises, and marginalized groups to strengthen FI and stimulate productive investment. Additionally, governments can encourage remittance inflows into formal financial institutions and promote saving through incentives, which will increase domestic deposits and support the expansion of credit supply.

Regulators play a critical role in maintaining affordable borrowing conditions by monitoring and managing lending interest rates and inflation. They should also ensure that government expenditure does not crowd out private sector investment, thereby protecting the positive link between FSD and CS. Financial institutions should develop tailored products and services to meet the diverse needs of households and businesses, particularly in rural and low-income areas. Leveraging mobile banking and other digital solutions, as demonstrated by successful cases like M-Pesa in Kenya and mobile finance reforms in Uganda, can further enhance financial access and inclusion.

In summary, the findings of this study demonstrate that enhancing financial sector development and credit access is crucial for improving financial inclusion and credit supply in East Africa. Effective policies must account for country-specific contexts, income levels, and the varying impacts of macroeconomic and institutional factors to ensure that financial growth translates into broader social and economic growth.

Despite its contributions, this study is subject to several limitations. It relies on secondary panel data from seven East African countries, which may include inconsistencies or missing values. The panel methods provide regional averages that may mask important country-specific dynamics, and the study does not conduct separate country-level analyses due to data constraints. The limited geographical scope also restricts the generalization of findings to other African regions. Moreover, the indicators used capture only selected dimensions of financial development, inclusion, and credit supply, excluding factors such as institutional quality or political stability. Future research should incorporate country-specific analyses, richer indicators, and broader geographical coverage.

Notes

1. In line with widely accepted definitions from the World Bank, IMF, Global Findex, and the Alliance for Financial Inclusion, this study defines financial sector development (FSD) as the improvement in the efficiency, depth, access, stability, and liberalization of financial institutions and financial markets.
2. Financial inclusion (FI) refers to the availability and effective use of affordable, accessible, and appropriate financial services by individuals and firms. This encompasses access to bank accounts, credit, savings instruments, insurance products, and digital financial services. Together, these concepts capture both the structural advancement of the financial system and the extent to which households and firms can meaningfully participate in it.

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Author contributions

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Data availability statement

Data used in this article is available from the authors upon request.

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