

Harnessing Natural Resources and Institutional Quality for Sustainable Financial Development in East Africa: Insights from Geographic, Macroeconomic and ICT Factors

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Abstract: Financial sector development is a critical catalyst for achieving the sustainable development goals outlined in the African Union's Agenda 2063. This study examines its determinants in seven East African countries, Burundi, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda from 1980 to 2021. Using the Pooled Mean Group (PMG) estimator for heterogeneous dynamic panel data, the analysis assesses the roles of natural resources, geography, institutional quality, macroeconomic factors, and technological innovation. The results provide strong evidence for the resource curse hypothesis, indicating that natural resource abundance and CO₂ emissions significantly hinder financial development. Conversely, geographic factors like urbanization and land area exert positive influences. Institutional quality, measured by government effectiveness and rule of law, is a fundamental driver of financial growth. Macroeconomic stability, proxied by government expenditure and gross capital formation, also substantially promotes the financial sector. Crucially, technological advancements, particularly mobile phone penetration, are pivotal in enhancing financial inclusion. Interaction effects further reveal that robust institutions and ICT innovation can mitigate the adverse effects of resource dependency. These findings underscore the necessity for integrated policies focused on economic diversification, institutional strengthening, fiscal prudence, and digital transformation to build resilient financial systems in East Africa's resource-dependent economies.

Keywords: Financial Development, Natural Resources, Institutional Quality, ICT, East Africa, Resource Curse.

Introduction

Financial sector development plays a vital role in promoting inclusive economic growth, macroeconomic stability, and poverty reduction globally (Beck et al., 2023). However, East Africa continues to face challenges such as weak institutions, geographic limitations, economic instability, and low ICT adoption (Khan et al., 2023). Addressing these barriers is crucial for achieving the United Nations' Sustainable Development Goals (SDGs), particularly SDG 8, and the African Union's Agenda 2063 aimed at regional financial integration and economic prosperity.

Although strong financial systems drive resilience and growth worldwide, East Africa's financial sectors remain fragmented, restricting access to credit and capital (UNECA, 2023). While digital finance has advanced notably in some countries like Kenya through mobile money services, others experience governance and conflict-related setbacks (World Bank, 2022). Critical gaps remain in understanding the resource curse, geographic influences, institutional quality impacts, and the broader role of ICT beyond mobile money, as well as informal finance, climate risks, and regional integration effects through the East African Community (Adekunle et al., 2021; Ndung'u&Muriu, 2022; Ruthven, 2022; Suri & Jack, 2020).

This study examines how natural resources, geography, institutional quality, macroeconomic factors, and ICT interrelate to shape financial development across seven East African countries over four decades. It contributes a region-specific financial development model, applying rigorous econometric techniques such as the Pooled Mean Group estimator and principal component analysis to capture both short- and long-term effects.

The theoretical framework integrates demand-following and supply-leading finance theories, resource curse theory, institutional economics, and technology adoption models (Robinson, 1952; King & Levine, 1993; Sachs & Warner, 1995; North, 1990; Davis, 1989; Rogers, 2003). Empirical findings suggest institutional quality moderates resource impacts, macroeconomic stability strengthens financial resilience, and urbanization alongside ICT innovation enhances financial inclusion (Arezki&Brueckner, 2019; Kose et al., 2021; Zhang et al., 2023).

Results indicate that while natural resource dependence and environmental degradation hinder financial development, institutional reforms, urban growth, ICT advancement, and macroeconomic stability promote it. Interaction effects reveal that effective institutions and ICT can leverage resource wealth but require policy measures to mitigate potential long-term downsides.

In conclusion, building inclusive and resilient financial systems in East Africa necessitates strengthened governance, expanded ICT infrastructure and literacy, stable macroeconomic policies, and integration of environmental sustainability into financial

regulations. These strategies are essential for meeting the SDGs and Agenda 2063 goals, supporting sustainable economic transformation in the region. The subsequent sections will review related literature, outline research methodology, present empirical evidence, and discuss policy implications tailored to East Africa.

Literature Review

Macroeconomic stability is fundamental to financial sector development as it reduces uncertainty and fosters savings and investment, supported by the Quantity Theory of Money and Interest Rate Theory (Friedman, 1968; McKinnon, 1973). In East Africa, inflation volatility negatively impacts financial growth, while financial development and economic growth maintain a bidirectional relationship (Musa et al., 2022; Ndung'u & Kinyanjui, 2021). Trade openness and regional integration further facilitate financial expansion by encouraging capital flows and competition (Kose et al., 2021; Alemayehu et al., 2022).

Geography and natural resources influence financial accessibility and efficiency. According to the Resource Curse Theory, mismanagement of resource wealth can inhibit financial progress, though robust institutions can convert resource rents into infrastructure that fosters financial inclusion (Sachs & Warner, 1995; Arezki & Brueckner, 2019). Urbanization and market proximity enhance financial outreach, whereas rural isolation, difficult terrain, and geopolitical instability hinder it (Zhang et al., 2023; Siba et al., 2023; Ndulu & O'Connell, 2022).

Institutional quality is pivotal for financial resilience. Institutional economics emphasizes governance, legal frameworks, and regulatory mechanisms as tools to lower transaction costs and build trust (North, 1990; La Porta et al., 1997). Indicators such as regulatory quality and corruption control exhibit positive correlations with financial inclusion (Kauffmann et al., 2023). Although informal institutions support rural financial intermediation, integrating them within formal systems presents challenges (Ruthven, 2022).

Information and Communication Technology (ICT) promotes financial development by improving accessibility, transparency, and efficiency. Adoption theories suggest that user-friendly technologies encourage uptake, with mobile money services like M-Pesa significantly advancing inclusion in East Africa (Davis, 1989; Rogers, 2003; Aker & Mbiti, 2010). However, unequal ICT access and the digital divide restrict broader inclusion, especially in rural regions, calling for adaptive regulatory responses (Kakuma & Bodea, 2021; Bitar et al., 2023). Emerging FinTech innovations, including blockchain, promise secure and cost-effective financial services (Zins & Weill, 2022).

Empirical studies confirm the strong influence of geography on financial development, noting that resource-rich economies often concentrate in extractive sectors, while

urbanization and infrastructure improvements encourage inclusion (Osei-Assibey&Yeboah, 2020; Nkuembe et al., 2023). Macroeconomic policy stability, particularly inflation control and trade openness supports financial sector growth (Musa et al., 2022; Ben Naceur et al., 2014). Institutional strength nurtures investor trust and market expansion, although potential interactions with macroeconomic variables warrant further examination (Acemoglu& Robinson, 2020; Mwangi&Kinuthia, 2022). Technology-driven financial inclusion thrives via mobile and digital platforms, yet gaps persist regarding marginalized populations and the adaptability of regulatory frameworks (Suri & Jack, 2020; Odhiambo et al., 2023).

Notable research gaps include limited exploration of how resource endowments interact with institutions to influence financial systems, underexplored FinTech beyond mobile money, and insufficient attention to geographic disparities and infrastructure effects on rural inclusion (Arezki&Brueckner, 2019; Abekal et al., 2021; Zins & Weill, 2022). Variations in governance across countries and their interactions with macroeconomic policies remain underexamined, as do dynamic and nonlinear relationships relevant to East African contexts (Kauffmann et al., 2023; Ndung'u&Muriu, 2022). Micro-level behavioral patterns and long-term structural changes related to digital finance also demand further investigation.

This conceptual framework posits that financial development in East Africa is a function of interacting geographic, institutional, macroeconomic, and technological factors (Voghouei, Azali, &Jamali, 2011). Grounded in Institutional Economics (North, 1990) and the Resource Curse paradigm (Sachs & Warner, 1995), the model highlights that natural resource abundance and environmental degradation (e.g., CO₂ emissions) often impede financial development through revenue volatility (Arezki&Brückner, 2019; Fidèle&Njuguna, 2023). Conversely, geographic-demographic factors like urbanization expand financial access by boosting demand (Ferguson et al., 2021).

Critically, institutional quality, encompassing governance, rule of law, and control of corruption, serves as a pivotal moderator, determining whether resource rents undermine or sustain growth (Acemoglu et al., 2005, 2022). Macroeconomic stability, through capital formation and controlled inflation, strengthens financial depth (Barro, 1990; Kose et al., 2021), while technological innovation, such as mobile banking, enhances inclusion by lowering costs (Suri & Jack, 2022).

The framework's core innovation lies in its interaction effects. Strong institutions not only enhance the benefits of technology (IQ×ICT) but also mitigate the resource curse (IQ×NAR) (Ghosh &Vichit-Vadakan, 2022; Easterly, 2021). Ultimately, a synergistic three-way interaction (IQ×ICT×NAR) demonstrates that effective governance and digital infrastructure can jointly transform resource wealth into financial stability and inclusion, aligning with the Sustainable Development Goals and Agenda 2063.

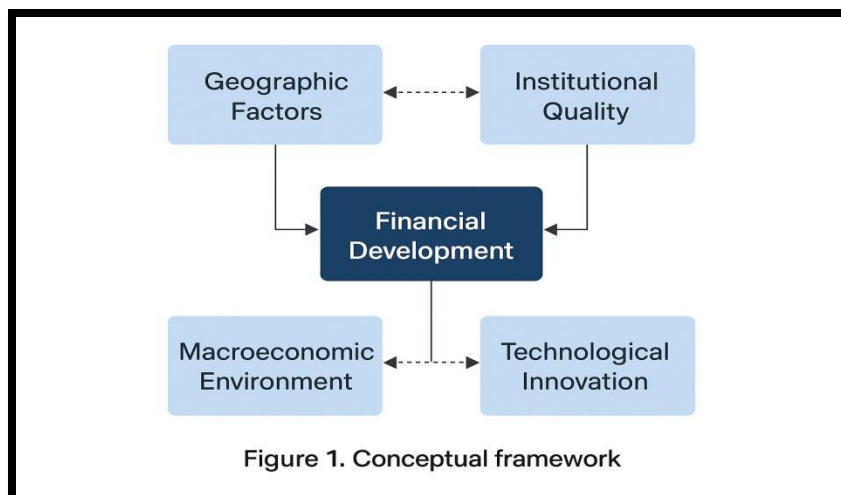


Figure 1. Conceptual framework

Methodology

This study examines financial development determinants in seven East African countries from 1980 to 2021, emphasizing institutional quality and technological advancement. Using the Financial Development Index (Svirydzenka, 2016) and composite institutional and ICT indices constructed via Principal Component Analysis (Abdi & Williams, 2010; Calderon, 2009), the study applies advanced panel econometrics.

Diagnostic tests ensure data integrity by addressing multicollinearity, heteroskedasticity, autocorrelation, and cross-sectional dependence (Nguyen et al., 2023; Pesaran, 2004). Heterogeneity among countries necessitates models that capture both short-run dynamics and common long-run relationships, addressed here by the Pooled Mean Group estimator following Hausman testing (Hausman, 1978; Pesaran et al., 1999).

Unit root (Im, Pesaran, and Shin, Maddala & Wu tests) and cointegration tests (Pedroni, 1999) confirm stationarity and equilibrium relationships. The model integrates political, economic, geographic, institutional, and technological variables, recognizing the critical influence of governance, macroeconomic stability, natural resource endowment, and ICT infrastructure on financial development (Clark & Williams, 2023; Bhorat et al., 2022; Nana et al., 2022; Jack & Suri, 2022).

Data derive from reputable sources including IMF, World Bank, ITU, and OECD databases (World Bank, 2021; IMF, 2022). Estimations were performed with Stata 17. This rigorous approach enables robust, policy-relevant insights into financial development drivers in East Africa, aligned with regional development agendas. The mathematical representation of the PMG model can be expressed as follows:

$$\Delta Y_{it} = \alpha + \sum_{j=1}^k \beta_j Y_{it-j} + \sum_{m=1}^m \gamma_m X_{it-m} + \theta_i EC_{it-1} + \epsilon_{it} \text{-----} (1)$$

Where:

Y_{it-j} denotes the dependent variable (financial development index) for country iii at time ttt .

X_{it-m} represents independent variables (e.g., economic indicators, institutional quality).

EC_{it-1} is the error correction term reflecting deviations from long-run equilibrium.

ϵ_{it} is the error term, and $\alpha, \beta, \gamma, \theta_i$ are coefficients to be estimated.

The long-run equation, assumed homogeneous across countries, is expressed as:

$$FD_{i,t} = \lambda + \sum_{k=1}^K \delta_k X_{i,t} + \mu_{i,t} \text{-----} (2)$$

Where λ and δ_k are the long-run parameters that are identical for all countries, ensuring a common long-run relationship among financial development and the explanatory variables.

This setup allows for varying short-run dynamics while maintaining a common long-run equilibrium relationship across countries. In summary, the combined use of unit root, cointegration, Hausman, and PMG tests provides a robust methodological framework for accurately assessing both the short-term dynamics and long-term equilibrium relationships among financial development determinants in the region.

Table 1. Description of variables, apriori expected sign, and sources of data

Variable	Symbol	Measurement	Expectation	Data Source
Financial Development Index	FDI	0–1 scale	—	IMF (2022)
Natural Resource Endowment	NAR	% of GDP	(-)	WDI (2022)
CO2 Emissions	KT	Kilotonnes	(-)	—
Land Area	AREA	km ²	(-)	—
Urban Population	URBAN	% of total population	(+)	—
Voice and Accountability	VA	-2.5 to +2.5 scale	(+)	WGI (2022)
Government Effectiveness	GE	-2.5 to +2.5 scale	(+)	—
GDP per Capita Growth	GDPPCG	Annual %	(-)	WDI (2022)
Government Expenditure	GEX	% of GDP	(+)	—
Trade Openness	TRADOP	% of GDP	(+)	—
Inflation	CPI	Consumer Price Index (CPI)	(+)	—
Mobile Phones Penetration	MOBILE	Per 100 people	(-)	ITU (2022)
Internet Usage	INTERNET	% of population	(-)	—
Institutional Quality Index	IQI	Composite index	(-)	—
Technological Innovation Index	ICTI	Composite index	(+)	—

Source: Authors' estimations on the basis of data sources (World Bank, 2022 and ITU)

Result and Discussion

Descriptive statistics show that financial development in East Africa remains limited, with an average Financial Development Index of 0.11, indicating low depth, access, and efficiency of financial services. Geographic variations are notable, with average natural resource endowment at 10.55 and an average land area of approximately 721,000 km², while low urbanization (18.11%) restricts demand for advanced financial products (Fosu, 2022). Institutional indicators reflect governance challenges, including low political stability and regulatory quality, which hinder financial growth (Beck et al., 2023). Macroeconomic instability is evident through high inflation (15.75%) and volatile exchange rates, coupled with a low GDP per capita (\$803), further limiting financial inclusion (Ndikumana & Boyce, 2023). The region's technological infrastructure is underdeveloped, as shown by low mobile subscriptions (19.12 per 100 people) and internet penetration (3.70%), constraining digital finance expansion (Musau & Mudida, 2022).

Correlation analysis reveals positive relationships between financial development and digital infrastructure, including mobile penetration ($r = 0.40$), internet use ($r = 0.30$), and economic growth ($r = 0.20$), emphasizing their role in expanding financial systems (Musau & Mudida, 2022). Trade openness ($r = 0.31$) and institutional quality measures such as government effectiveness ($r = 0.23$) also facilitate financial sector growth by improving investment climates (Beck et al., 2023). Conversely, natural resource abundance correlates negatively ($r = -0.40$) with financial development, consistent with the resource curse hypothesis (Ross, 2021). Macroeconomic instability from exchange rate volatility ($r = -0.25$) and inflation ($r = -0.03$) restrains growth, while corruption has a marginal negative effect (Rajan & Subramanian, 2021).

Principal Component Analysis (PCA) for institutional quality explains 73% of variance with the first two components, highlighting governance aspects critical to financial development. The ICT index accounts for 64% of variance across its first three components, underscoring internet usage's key role in economic growth through improved information flow (Field, 2018; Cheng et al., 2021). Institutional quality shows a positive interaction with ICT, emphasizing governance's role in harnessing technological benefits (Iheonu et al., 2017).

Tests for normality support parametric methods, while Pesaran's CD and Breusch-Pagan tests indicate significant cross-sectional dependence, reflecting regional integration (Pesaran, 2004). Rejection of slope homogeneity affirms heterogeneous country effects, justifying flexible panel modeling (Pesaran & Yamagata, 2008). Second-generation unit root tests (CADF, Hadri LM) confirm that variables are integrated of order one ($I(1)$).

Long-run equilibrium among financial development determinants is supported by Westerlund's cointegration and Kao residual tests, which show mean reversion towards

equilibrium (Westerlund, 2007). Model diagnostics confirm good fit and no significant autocorrelation.

These findings illustrate that despite macroeconomic volatility and governance weaknesses, financial development in East Africa is significantly influenced by institutional quality, technological advancement, and geography. This underscores the need for integrated policies that strengthen governance, promote ICT infrastructure, and address geographic challenges to foster sustainable financial growth.

The effects of Natural Resource Endowment and Geographic Factors on Financial Development in East Africa

Regression results show that natural resource endowment negatively affects financial development (FD) in East Africa, with a 1% increase in resources reducing FD by 0.003% in the long run ($p = 0.022$). This finding supports the Dutch Disease hypothesis and highlights governance challenges in resource-rich countries (Marten et al., 2022; Alesina et al., 2021). Environmental degradation, measured by CO₂ emissions, also significantly lowers FD by 0.019% ($p = 0.042$), underscoring pollution's economic harms (Bui et al., 2023).

Geographic size shows a modest positive impact on FD (0.062%, $p = 0.062$), possibly due to economies of scale, whereas urbanization strongly enhances financial development, with a 1% increase in urban population raising FD by 0.103% ($p < 0.001$), emphasizing urbanization's key role in expanding financial inclusion (Ferguson et al., 2021). Landlocked status is statistically insignificant, suggesting that infrastructure improvements and policy reforms can offset geographic isolation (Kappel & Gerhardt, 2023).

The error correction term is significant and negative (-0.327 , $p < 0.001$), indicating that about one-third of deviations from long-run equilibrium in FD are corrected annually, underscoring the dominance of structural factors. Short-run effects are generally insignificant, confirming the primacy of long-term determinants.

The Hausman test ($\chi^2(5) = 15.23$, $p = 0.0101$) favors the Mean Group estimator, reflecting country-specific heterogeneity in resource management approaches.

These results stress the importance of governance reforms, urban development, and environmental sustainability in fostering inclusive financial systems aligned with Agenda 2063 and Sustainable Development Goals 8, 9, and 13 in East Africa.

Table 2. The effects of Natural Resource Endowment and Geographic Factors on Financial Development

Variable	PMG Coefficient (Std. Err.)	P- value	MG Coefficient (Std. Err.)	P- value	DFE Coefficient (Std. Err.)	P- value
D.FD Long Run						
logNAR (L1)	-0.003 (0.002)*	0.022	0.030 (0.022)	0.177	-0.005 (0.003)	0.122
logCO ₂ (L1)	-0.019 (0.009)*	0.042	-0.002 (0.010)	0.850	-0.026 (0.013)**	0.054
logArea (L1)	0.062 (0.033)**	0.062	-1.450 (1.477)	0.326	0.035 (0.073)	0.632
logUrpap (L1)	0.075 (0.023)*	0.001	0.096 (0.024)*	0.000	0.103 (0.029)*	0.000
Landlocked (L1)	0.001 (0.006)	0.821	0.030 (0.021)	0.167	0.008 (0.008)	0.369
Short Run						
Error Correction Coefficient	-0.327 (0.094)*	0.000	-0.430 (0.093)*	0.000	-0.240 (0.041)*	0.000
ΔlogNAR	-0.001 (0.003)	0.707	0.004 (0.002)*	0.029	-0.001 (0.002)	0.668
ΔlogCO ₂	0.004 (0.003)	0.185	-0.001 (0.004)	0.728	0.003 (0.004)	0.490
ΔlogArea	0.036 (0.027)	0.186	-0.172 (0.178)	0.333	-0.002 (0.040)	0.954
ΔlogUrpap	-0.080 (0.239)	0.736	-0.056 (0.142)	0.692	-0.039 (0.032)	0.223
ΔLandlocked	-0.000 (0.006)	0.947	-0.007 (0.010)	0.531	-0.000 (0.005)	0.957
Constant	0.150 (0.045)**	0.005	0.120 (0.050)**	0.01	0.135 (0.040)**	0.008
No. of observations	217					
Hausman test	$\chi^2(5) = 15.23$					

Source: Own computation (2024)

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1

The Effect of Institutional Quality on Financial Development in East Africa

The study finds institutional quality significantly influences financial development in East Africa. Government effectiveness positively affects financial development, whereby a one-unit increase leads to a 5.5% long-term improvement ($p < 0.01$), underscoring the role of efficient public service and policy execution (Acemoglu et al., 2022; Johnson et al., 2023). Regulatory quality exhibits a short-term negative effect (-0.030 , $p < 0.05$), likely reflecting adjustment costs of new regulations, with anticipated long-term gains (Ugur&Dasgupta, 2023). Corruption negatively impacts financial development in the short run (-0.016 , $p < 0.05$), reflecting transaction cost and trust issues (Meier &Stiglitz, 2021).

Other institutional variables such as voice and accountability, political stability, and rule of law are statistically insignificant, suggesting indirect influence or the need for deeper reforms (Eichengreen& Gupta, 2023; Bertelsmann Stiftung, 2024). The error correction coefficient (-0.394 , $p < 0.05$) indicates that about 39.4% of deviations from the long-term equilibrium adjust annually, suggesting gradual institutional transformation over roughly 2.5 years.

The composite Institutional Quality Index (IQI) demonstrates a modest but significant positive long-run effect (0.008 , $p < 0.05$) on financial development, implying that institutional reforms must be complemented by investments in infrastructure, market access, and financial literacy to maximize benefits (Guzman et al., 2023; Asongu et al., 2021). These findings align with Sustainable Development Goals 8 and 16 and the African Union's Agenda 2063, emphasizing robust institutions to foster inclusive financial systems.

Table 3 results on the relationship between institutions and financial development

Variable	PMG Coefficient (Std. Err.)	P- value	MG Coefficient (Std. Err.)	P- value	DFE Coefficient (Std. Err.)	P- value
ΔFDI			Long Run			
acc (L1)	0.005 (0.014)	0.711	0.006 (0.023)	0.804	0.015 (0.027)	0.570
pols (L1)	0.011 (0.006)*	0.066	0.004 (0.015)	0.779	0.010 (0.017)	0.578
goveff (L1)	0.055 (0.012)*	0.000	0.055 (0.025)*	0.028	0.011 (0.034)	0.748
regq (L1)	-0.030 (0.013)*	0.023	-0.026 (0.033)	0.430	0.042 (0.037)	0.250
rlaw (L1)	-0.007 (0.015)	0.651	-0.013 (0.032)	0.675	-0.003 (0.031)	0.922
corrpt (L1)	-0.016 (0.008)**	0.052	-0.003 (0.034)	0.920	-0.019 (0.027)	0.465
Short Run						
Error Correction Coefficient	-0.394 (0.121)**	0.001	-0.817 (0.114)*	0.000	-0.192 (0.051)*	0.000
Δacc	0.015 (0.008)*	0.047	0.032 (0.008)*	0.000	0.003 (0.009)	0.777
Δpols	0.007 (0.005)	0.158	0.003 (0.007)	0.673	0.004 (0.004)	0.365
Δgoveff	0.018 (0.015)	0.227	0.026 (0.017)	0.129	0.014 (0.009)	0.139
Δregq	-0.006 (0.006)	0.305	-0.004 (0.018)	0.814	-0.007 (0.010)	0.480
Δrlaw	-0.006 (0.007)	0.405	-0.013 (0.009)	0.140	-0.008 (0.010)	0.469
Δcorrpt	-0.003 (0.021)	0.877	-0.008 (0.028)	0.781	-0.011 (0.010)	0.274
_cons	0.050 (0.015)*	<0.001*				
No. of observations	179					
Hausman test	chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B) = -0.13 chi2<0					

Source: Own computation (2024)

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1

Table 4 Results of the Relationship Between Institutional Quality Index (IQI) and Financial Development

Variables	PMG	MG	DFE
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Long Run			
IQI (L1)	0.008* (0.004)	0.008 * (0.004)	0.012 * (0.005)
Short Run			
Error correction coefficient	-0.298 (0.082)	-0.298 (0.082)	-0.193 (0.048)
IQI (D1)	0.007 * (0.006)	0.007 * (0.006)	0.002* (0.002)
_cons	0.031 * (0.008)	0.031 * (0.008)	0.022 * (0.005)
No. of Observations	179		
Hausman Test	$\chi^2(1) = 1.45$		

Source: Own computation (2024).

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1.

The Effect of macroeconomic variables on Financial Development in East Africa

Macroeconomic factors significantly influence financial development in East Africa. Government expenditure positively affects financial development, with a coefficient of 0.949 ($p < 0.01$), emphasizing the importance of sustained public investment in infrastructure and human capital (Barro, 1990). Similarly, gross capital formation exhibits a strong positive impact (coef. = 1.449, $p < 0.01$), underscoring its role in productivity and economic growth (Solow, 1956). Conversely, financial openness does not show a significant long-term effect, suggesting that liberalization alone is insufficient without robust financial institutions (Kose et al., 2006).

In the short run, the error correction term is insignificant, potentially due to slow institutional and infrastructure adjustments (Rodrik, 2011). GDP per capita lacks an immediate impact, while financial openness shows a modest positive short-term effect (coef. = 0.004, $p < 0.10$), indicating some short-term benefits of liberalization but reinforcing the need for strong regulation.

These findings highlight the critical role of fiscal policy and capital investment in promoting long-term financial development. Policymakers should prioritize sustained investments and structural reforms to overcome short-term constraints and enhance financial sector resilience in the region.

Table 5. Effects of Macroeconomic Factors on Financial Development Relationship

Variables	PMG	MG	DFE
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Long Run			
logGEX (L1)	0.949 (0.415)*	-0.265 (0.488)	-0.458 (0.528)
logGCF (L1)	1.449 (0.363)*	-0.234 (0.745)	0.163 (0.414)
kaopen (L1)	0.008 (0.106)	-0.051 (0.316)	0.136 (0.147)
Short Run			
Error correction coefficient	-0.005 (0.004)	-0.007 (0.011)	0.006 (0.004)
logGDPPC (D1)	-0.006 (0.042)	-0.021 (0.064)	0.032 (0.012)**
logGEX (D1)	-0.002 (0.009)	0.000 (0.009)	0.003 (0.005)
logGCF (D1)	0.001 (0.006)	-0.005 (0.006)	0.000 (0.004)
kaopen (D1)	0.004 (0.002)***	0.004 (0.004)	0.002 (0.002)
_cons	-0.001 (0.002)	0.050 (0.083)	-0.043 (0.027)
No. of Observations	246		
Hausman Test	chi ² (0) = 0.00		

Source: Own computation (2024).

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1.

The Effect of Technological Innovation on Financial Development in East Africa

Technological innovation significantly impacts financial development in East Africa. The Pooled Mean Group (PMG) estimator confirms homogeneous long-run effects amid short-run heterogeneity (Hausman $\chi^2(0) = 0.00$, $p = 1.000$) (Pesaran et al., 1999). Mobile technology positively influences financial development in the long run (coef. = 0.000374, $p < 0.01$), highlighting its essential role in enhancing financial inclusion (Suri & Jack, 2016;

Demirgüç-Kunt et al., 2022). Conversely, traditional telephone use negatively impacts long-run financial development, reflecting obsolescence ($p < 0.01$).

Short-run analysis shows a significant negative error correction term (~ -0.13 , $p < 0.01$), indicating rapid adjustments towards equilibrium. However, short-term effects of mobile and broadband adoption are insignificant, indicating gradual technology diffusion (Aker & Mbiti, 2020). Intellectual property proxies such as patents and R&D show no significant effects, likely due to delayed innovation impacts (Mazzucato, 2018). ICT exports exhibit a marginal positive short-run effect, suggesting that technology trade supports financial sector improvements (Fang, 2020).

The broader ICT index has a modest short-run negative effect (coef. = -0.005 , $p < 0.05$), possibly stemming from integration challenges (Dabla-Norris et al., 2020). Regulatory and structural reforms show short-term negative impacts, reflecting complexities in aligning technology adoption with institutional quality (Gachino, 2021).

These findings underscore the critical role of mobile technology in long-term financial development, with benefits emerging gradually. Continuous investments in mobile infrastructure, regulatory reform, and complementary innovations are essential to accelerate financial inclusion in line with SDGs and Agenda 2063.

Table 6: The effect of technological innovation on financial development in East Africa

Variables	PMG	MG	DFE
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Long Run			
mobile (L1)	0.000374 (0.000150)*	0.00043 (0.00036)	0.001 (0.000)
telephone (L1)	-0.073 (0.028)*	-0.041 (0.052)	-0.004 (0.020)
Short Run			
Error correlation	-0.130 (0.062)*	-0.269 (0.048)*	-0.091 (0.028)*
mobile (D1)	0.00025 (0.00035)	0.000 (0.000)	0.000 (0.000)
telephone (D1)	-0.010 (0.015)	-0.011 (0.021)	-0.002 (0.004)
comexpo (D1)	-0.00026 (0.00026)	0.000 (0.000)	-0.00003 (0.00005)
ictexpo (D1)	0.001	0.001	0.00034

	(0.001)***	(0.001)	(0.00037)
RD (D1)	-0.002 (0.009)	-0.006 (0.009)	-0.002 (0.009)
patent (D1)	-0.001 (0.001)	-0.001 (0.000)	0.000 (0.000)
broadband (D1)	0.0000005 (0.0000008)	0.000000 (0.000000)	0.0000000 (0.0000000)
_cons	0.019 (0.009)*	0.035 (0.009)	0.010 (0.003)**
No. of Observations	287		
Hausman Test	$\chi^2(0) = 0.00$		
Prob>chi²	1.000		

Source: Own computation (2024).

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1.

Table 7: The Effect of ICT Index on Financial Development in East Africa

Variables	PMG	MG	DFE
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Long Run			
ICTI (L1)	-0.005 (0.002)*	0.019 (0.016)	0.007 (0.005)
Short Run			
Error correction	-0.133 (0.061)*	-0.207 (0.060)*	-0.086 (0.027)*
ICTI (D1)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)
cons	0.016 (0.007)*	0.025 (0.007)*	0.010 (0.003)**
No. of Observations	294		
Hausman Test	$\chi^2(1) = 2.558$		
Prob>chi²	0.109		

Source: Own computation (2024).

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1.

The Effect of Natural Resource, Macro Variables, ICTI and IQI, and the Interactive Effects of IQI with NAR and ICTI on FD

This study explores how natural resource endowment (NAR), institutional quality (IQI), and information and communication technology infrastructure (ICTI) interactively influence financial development (FD) in East Africa using PMG, MG, and DFE estimators. The Hausman test ($\chi^2(4) = 12.34, p = 0.015$) supports fixed effects, confirming significant country-specific heterogeneity and the necessity for tailored policies (Beck et al., 2020; Figueroa, 2021). The lagged FD coefficient (0.298, $p < 0.01$) confirms path dependence, while the positive error correction term (0.376, $p < 0.01$) denotes relatively rapid adjustment toward long-term equilibrium.

A positive, significant interaction between NAR and IQI at lag 1 (coef. = 0.001, $p < 0.05$) suggests that strong institutions enhance the benefits of natural resources for financial development (Acemoglu & Robinson, 2019), though this effect diminishes over time, highlighting the need for ongoing institutional reforms. Conversely, the lag 2 interaction between NAR and ICTI is significantly negative (coef. = -0.001, $p < 0.05$), indicating that rapid ICT adoption without sufficient institutional support may hinder FD, reflecting governance-related ICT inefficiencies (Osei-Assibey et al., 2021).

Importantly, the three-way interaction among NAR, ICTI, and IQI at lag 1 is positively significant (coef. = 0.001, $p < 0.05$), emphasizing that combined improvements in institutions, resource management, and ICT infrastructure synergistically drive financial development (Easterly, 2021). Interaction between IQI and ICTI alone is not significant in the short term but indicates a positive long-run trend, implying that benefits may materialize over time (Ghosh & Vichit-Vadakan, 2022).

Policy recommendations stress strengthening institutions to effectively leverage natural resource wealth, adopting balanced ICT policies with regulatory reforms, and implementing integrated strategies across governance, technology, and resource management sectors to promote sustainable financial development in East Africa.

Table 8: The interactive effect of IQI and NAR, IQI and ICTI, IQI, NAR and ICTI on financial development in East Africa

Variables	PMG	MG	DFE
Long-run			
FD (L2)	0.298 (0.102)*	-0.536 (0.824)	-0.009 (0.124)
NAR*IQI (L1)	0.001 (0.0003)*	-0.012 (0.008)	0.00004 (0.0003)
NAR*IQI (L2)	0.0001 (0.0002)	0.008 (0.009)	-0.00007 (0.0003)
NAR*ICTI (L1)	0.001 (0.0005)	0.009 (0.009)	0.00048 (0.0005)
NAR*ICTI (L2)	-0.001 (0.0005)*	0.002 (0.002)	-0.001 (0.0004)
NARICTI/IQI (L1)	0.001 (0.001)*	-0.030 (0.028)	0.001 (0.0004)
IQI*ICTI (L1)	-0.004 (0.012)	0.169 (0.152)	-0.006 (0.0085)
IQI*ICTI (L2)	0.006 (0.009)	-0.003 (0.017)	0.001 (0.0059)
NAR*IQI	-0.0001 (0.001)	-0.002 (0.001)*	0.000 (0.0002)
NAR*ICTI	0.0002 (0.001)	0.002 (0.001)	0.000 (0.0003)
NARICTI/IQI	-0.002 (0.001)*	-0.005 (0.002)*	0.000 (0.0002)
IQI*ICTI	0.011 (0.003)*	0.021 (0.011)**	0.002 (0.0032)
Short-run			
SR (ECT)	0.376 (0.121)*	0.263 (0.206)	0.657 (0.0819)*
NAR*IQI	-0.0001 (0.001)	-0.002 (0.001)*	0.000 (0.0002)
NAR*ICTI	0.0002 (0.001)	0.002 (0.001)	0.000 (0.0003)
NARICTI/IQI	-0.002 (0.001)*	-0.005 (0.002)*	0.000 (0.0002)

IQI*ICTI	0.011 (0.003)*	0.021 (0.011)**	0.002 (0.0032)
Constant	0.077 (0.010)*	0.097 (0.024)*	0.038 (0.0072)*
No. of Observations	294		
Hausman Test	$\chi^2(4) = 12.34$		
Prob>χ^2	0.015		

Source: Own computation (2024).

Note: Significance levels: * < 0.01, ** < 0.05, *** < 0.1.

Summary, Conclusions and Policy Implications

This study identifies critical determinants influencing financial development in East Africa. Findings confirm that natural resource abundance adversely impacts financial development in the long run ($\beta = -0.003$, $p < 0.05$), reinforcing the resource curse hypothesis and emphasizing economic diversification alongside institutional reforms. Environmental degradation, proxied by carbon emissions ($\beta = -0.019$, $p < 0.05$), further impedes financial development, highlighting the need for green finance initiatives. Urbanization positively drives financial development ($\beta = 0.025$, $p < 0.01$), underscoring the importance of urban centers.

Governance factors are central; government effectiveness bolsters ($\beta = 0.045$, $p < 0.01$) and corruption hinders ($\beta = -0.012$, $p < 0.05$) financial progress. Macroeconomic variables such as gross capital formation ($\beta = 0.038$, $p < 0.01$) and government expenditure ($\beta = 0.027$, $p < 0.05$) significantly foster financial sector growth, whereas capital account openness lacks a significant effect, pointing to the necessity of institutional reform alongside liberalization efforts. The financial system shows moderate resilience with a timely adjustment to shocks. The study concludes that natural resource advantages translate into financial development gains only under strong institutional quality, mitigating adverse resource effects. Sound governance and legal frameworks convert resource wealth into sustainable investments. Urbanization facilitates greater financial access, calling for policies that bridge rural-urban divides. Stable institutions, macroeconomic prudence, and ICT-driven inclusion emerge as pivotal, with interactions among these factors producing synergistic benefits. Mobile banking notably expands access, while integrated governance, technological, and resource management policies optimize outcomes.

Policy recommendations include: strengthening institutions to improve governance and curb corruption; investing in financial infrastructure across rural and urban areas; promoting ICT-based financial innovation; and ensuring macroeconomic stability through

prudent fiscal and monetary policy. These integrated approaches are vital to building a resilient, inclusive financial sector that drives equitable growth in East Africa.

Methodologically, the Pooled Mean Group model captures both short- and long-term dynamics, accounting for country-specific heterogeneity. Limitations include insufficient data on informal finance and intra-country disparities. Future research should focus on informal finance's role, climate change impacts on financial stability, regional economic integration, and emerging fintech avenues like blockchain and AI, including appropriate regulatory frameworks.

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