

## The Impact of Telecommunication Infrastructure on Financial Development in Sub-Saharan Africa

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**Abstract:** This study examines the relationship between telecommunication infrastructure and financial development in Sub-Saharan Africa (SSA) using panel data from 25 countries over the period 2000–2024. Employing Panel Least Squares (PLS) estimation and Pedronico integration tests, the analysis reveals that mobile telephone density and fixed internet broadband density exert significant positive effects on financial development, while fixed telephone density shows no significant impact. The aggregate measure of telephone and broadband density also demonstrates a positive significant relationship with financial development. Cointegration tests confirm a long-run equilibrium relationship between ICT infrastructure and financial development. These findings underscore the transformative potential of modern digital infrastructure in fostering financial inclusion and deepening financial markets across the region. The study recommends prioritizing investments in mobile networks and broadband infrastructure while redirecting resources away from obsolete fixed-line systems.

**Keywords:** Telecommunication infrastructure, financial development, mobile penetration, broadband internet, Sub-Saharan Africa

### 1. Introduction

The relationship between information and communication technology (ICT) infrastructure and economic development has garnered substantial scholarly attention over the past two decades. In Sub-Saharan Africa (SSA), where traditional banking infrastructure remains underdeveloped and financial exclusion persists, telecommunication infrastructure has emerged as a critical enabler of financial development. The region has witnessed unprecedented growth in mobile telephony, with penetration rates exceeding 100% in several countries, facilitating revolutionary financial innovations such as mobile money platforms (GSMA, 2022).

Financial development—encompassing financial depth, access, efficiency, and stability—represents a cornerstone of sustainable economic growth. It facilitates capital accumulation, resource allocation, and risk management while reducing poverty and inequality (Sahay et al., 2015). In SSA, however, financial systems have historically struggled with limited infrastructure, high transaction costs, and low inclusion rates. The advent of digital technologies, particularly mobile banking and internet-based financial services, presents transformative opportunities to overcome these structural constraints.

Despite the growing recognition of ICT's developmental potential, significant knowledge gaps persist regarding the specific mechanisms through which different components of telecommunication infrastructure influence financial development. While mobile money success stories from Kenya and Ghana have attracted considerable attention, systematic empirical evidence examining the distinct contributions of mobile telephony, fixed-line infrastructure, and broadband internet remains limited. Furthermore, the long-run dynamics between ICT infrastructure and financial development in SSA require deeper investigation to inform sustainable policy frameworks.

This study addresses these gaps by examining five specific research objectives: (1) assessing the impact of mobile telephone density on financial development; (2) evaluating the effect of fixed telephone density; (3) analyzing the influence of fixed internet broadband density; (4) determining the aggregate impact of combined telecommunications infrastructure; and (5) establishing whether long-run relationships exist between ICT infrastructure and financial development.

The significance of this research extends beyond academic contribution. For policymakers, understanding which infrastructure components most effectively promote financial development enables strategic resource allocation in constrained budget environments. For development practitioners, the findings provide evidence-based guidance for designing ICT interventions that maximize financial inclusion outcomes. The study also contributes to theoretical discourse by integrating insights from endogenous growth theory, financial intermediation theory, and technology adoption frameworks.

The remainder of this article proceeds as follows: Section 2 reviews relevant literature; Section 3 presents the theoretical framework; Section 4 describes the data and methodology; Section 5 discusses the empirical results; and Section 6 concludes with policy implications.

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## 2. Literature Review

### 2.1 ICT Infrastructure and Financial Development: Conceptual Foundations

Information and Communication Technology encompasses the technological tools and resources used to transmit, store, create, share, and manage information. Core components include mobile cellular networks, fixed telephone lines, and broadband internet infrastructure (ITU, 2021). In SSA, ICT development has followed a distinctive trajectory characterized by mobile-first adoption, leapfrogging traditional fixed-line infrastructure that dominated Western development patterns.

Financial development represents a multidimensional concept involving improvements in the quantity, quality, and efficiency of financial intermediation services. The International Monetary Fund identifies four key dimensions: financial depth (size and liquidity of markets), access (ability to use financial services), efficiency (resource allocation performance), and stability (resilience to shocks) (Svirydzenka, 2016). Traditional measurement approaches relied on monetary aggregates such as private sector credit to GDP or M2 to GDP ratios. Contemporary research increasingly employs composite indices capturing multiple dimensions, acknowledging that financial development transcends simple credit availability.

The ICT-financial development nexus operates through multiple channels. First, ICT reduces transaction costs by enabling real-time communication and digital record-keeping, making financial services economically viable for previously excluded populations. Second, ICT enhances information availability, reducing asymmetries that constrain lending decisions. Third, digital platforms enable innovative service delivery models—mobile banking, agent networks, and digital payments—that circumvent physical infrastructure limitations. Fourth, ICT integration improves operational efficiency within financial institutions, reducing overhead costs and improving profitability.

### 2.2 Empirical Evidence from Sub-Saharan Africa

The empirical literature on ICT and financial development in SSA has expanded considerably, though with notable limitations in scope and methodology. Early studies emphasized mobile telephony's transformative potential. Mbiti and Weil (2016) demonstrated that M-Pesa in Kenya improved savings behavior and remittance patterns, while Suri and Jack (2016) found that mobile money lifted 2% of Kenyan households out of poverty. These micro-level findings suggested

substantial macroeconomic implications, yet cross-country empirical validation remained limited.

Asongu and Nwachukwu (2017) examined mobile phone penetration across 49 African countries, finding positive associations with inclusive human development, though their analysis did not isolate financial development outcomes specifically. Andrianaivo and Kpodar (2015), analyzing 44 African countries, established that ICT contributes significantly to financial inclusion and economic growth, but their composite ICT measure precluded disaggregated analysis of specific infrastructure components.

Recent scholarship has begun addressing these limitations. Raza et al. (2021) compared ICT impacts across low- and high-income countries, confirming positive effects on financial development that are stronger in developed economies, suggesting infrastructure quality thresholds may exist. Oughton (2021) employed simulation modeling for broadband expansion in six African countries, finding cost-effective pathways for universal service, though without direct linkage to financial outcomes.

Studies examining fixed-line infrastructure specifically are scarce, reflecting the technology's declining relevance. However, Mothobi and Grzybowski (2017) noted that infrastructure deficits—including inadequate fixed-line systems—hinder mobile money adoption, suggesting potential complementarities between infrastructure types that merit further investigation.

Broadband internet's role has attracted increasing attention as connectivity expands. Vu (2020) observed that broadband access significantly enhances banking sector efficiency in developing countries, while Koutroumpis et al. (2021) emphasized data markets' potential to improve financial services through better information. These studies, however, often lack SSA-specific focus or employ cross-sectional designs that cannot establish temporal dynamics.

### 2.3 Research Gaps

Several critical gaps characterize the existing literature. First, most studies employ composite ICT indices, obscuring the distinct contributions of mobile telephony, fixed lines, and broadband. This aggregation is problematic given SSA's unique infrastructure trajectory and the varying relevance of different technologies across development contexts. Second, longitudinal analyses examining long-run relationships remain scarce, with most studies employing cross-sectional or short-panel designs. Third, the treatment of SSA as homogeneous overlooks significant cross-country heterogeneity in institutional quality, regulatory environments, and financial system maturity. Fourth, recent

empirical work using comprehensive financial development indices rather than single indicators remains limited.

This study addresses these gaps through disaggregated analysis of specific infrastructure components, long-panel econometric techniques accommodating country heterogeneity, and employment of a composite Financial Development Index capturing multiple dimensions of financial system performance.

### **3. Theoretical Framework**

This study integrates three theoretical perspectives to explain the ICT-financial development relationship: Endogenous Growth Theory, Financial Intermediation Theory, and the Technology-Enabled Financial Inclusion Paradigm.

#### **3.1 Endogenous Growth Theory**

Romer's (1990) Endogenous Growth Theory emphasizes technological change and knowledge accumulation as drivers of sustained economic growth. Unlike neoclassical models where technology enters as an exogenous residual, endogenous growth theory treats innovation as economically determined, with knowledge spillovers generating increasing returns to scale.

Applied to the ICT-financial development nexus, this framework suggests that telecommunication infrastructure investments generate productivity gains that compound over time. Mobile networks and broadband infrastructure facilitate knowledge diffusion, enabling financial institutions to adopt superior technologies and practices. The theory predicts that ICT infrastructure will exhibit long-run relationships with financial development, as technological capabilities accumulate and progressively transform financial service delivery. Furthermore, the theory accommodates heterogeneous effects across countries, as institutional and human capital factors influence the capacity to absorb and deploy ICT innovations effectively.

#### **3.2 Financial Intermediation Theory**

Traditional financial intermediation theory emphasizes institutions' roles in mobilizing savings, allocating capital, and managing risk (Sahay et al., 2015). ICT transforms intermediation by reducing information asymmetries, lowering operational costs, and expanding outreach capabilities. Mobile banking platforms exemplify this transformation, enabling institutions to serve previously unbanked populations without expensive branch networks.

The theory predicts differential impacts across infrastructure types based on their intermediation capabilities. Mobile telephony excels at retail payment services and basic savings products, reaching mass markets efficiently. Broadband internet supports more complex intermediation activities—credit scoring,

investment management, and institutional connectivity—that deepen financial markets. Fixed-line telephony, constrained by limited mobility and higher costs, offers fewer distinctive advantages in contemporary contexts.

### **3.3 Technology-Enabled Financial Inclusion Paradigm**

This emerging framework focuses specifically on digital technologies' potential to overcome barriers to financial inclusion (World Bank, 2018). It emphasizes three dimensions: affordability (reducing service costs), accessibility (expanding geographic reach), and usability (designing appropriate interfaces for diverse populations). The paradigm highlights that infrastructure alone is insufficient; effective inclusion requires complementary investments in digital literacy, regulatory frameworks, and ecosystem development.

For SSA, this paradigm suggests mobile infrastructure will demonstrate particularly strong financial development effects given its accessibility advantages for low-income, rural populations. Broadband effects may be more pronounced in urban, commercially oriented financial activities. The paradigm also implies aggregate infrastructure measures should capture synergies between complementary technologies.

These theoretical perspectives collectively generate testable propositions: (1) mobile telephone density will positively affect financial development, particularly access dimensions; (2) fixed telephone density will demonstrate weak or negative effects reflecting technological obsolescence; (3) broadband density will positively influence financial development, particularly depth and efficiency dimensions; (4) aggregate infrastructure will exhibit positive effects exceeding individual components due to complementarities; and (5) long-run equilibrium relationships will exist between ICT infrastructure and financial development.

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## **4. Data and Methodology**

### **4.1 Data Sources and Sample**

This study employs annual panel data covering 25 Sub-Saharan African countries from 2000 to 2024. Country selection reflects data availability while ensuring regional representation across East, West, Southern, and Central Africa. The sample includes: Angola, Benin, Botswana, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Mali, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

Data sources include the World Development Indicators (WDI) database for economic and demographic variables, the International Telecommunication Union (ITU) for infrastructure indicators, and the IMF Financial Development

Index database for the dependent variable. The resulting panel comprises 625 observations (25 countries × 25 years), with minor variations due to missing data for specific variables.

#### 4.2 Variable Measurement

##### **Dependent Variable: Financial Development Index (FDI)**

The Financial Development Index serves as the dependent variable, measured as a composite indicator incorporating financial depth, access, efficiency, and stability dimensions. Following Svirydzenka (2016), the index combines Financial Institutions Index (FII) and Financial Markets Index (FMI) components, with higher values indicating more developed financial systems. The index ranges from -12.05 to 14.21 in the sample, with mean 6.03 and standard deviation 5.46.

##### **Independent Variables**

Four telecommunication infrastructure indicators are examined:

1. **Mobile Cellular Subscriptions (MCS):** Mobile telephone density measured as subscriptions per 100 population. This captures the penetration of mobile networks enabling mobile banking and digital financial services. Sample mean: 56.52 (SD: 45.81), ranging from 0.02 to 185.56.
2. **Fixed Telephone Subscriptions (FTS):** Fixed-line telephone density per 100 population, measuring traditional landline infrastructure. Sample mean: 3.79 (SD: 7.19), ranging from 0.002 to 36.88.
3. **Fixed Broadband Subscriptions (FBS):** Fixed internet broadband density per 100 population, indicating high-speed internet access. Sample mean: 1.18 (SD: 1.09), ranging from 0.0002 to 3.50.
4. **Total Broadband and Telephone Subscriptions (TBS):** Aggregate measure combining mobile cellular and fixed broadband subscriptions per 100 population, capturing overall telecommunications infrastructure. Sample mean: 4.97 (SD: 7.24), ranging from 0.22 to 40.09.

##### **Control Variables**

Two control variables are included: ICT Goods Exports (ICTGE) as a share of total exports, capturing technological development and international competitiveness; and Population Growth (POPG), the annual percentage change in population, accounting for demographic dynamics affecting financial service demand.

#### 4.3 Econometric Methodology

The analysis proceeds in three stages: stationarity testing, cointegration analysis, and panel regression estimation.

### Stationarity Testing

The Levin, Lin and Chu (LLC) panel unit root test examines variable stationarity. This test assumes a common unit root process and is appropriate for balanced panels. Results indicate that FDI, MCS, FTS, FBS, ICTGE, and POPG are stationary at levels (I(0)), while TBS requires first differencing to achieve stationarity (I(1)). The mixture of I(0) and I(1) variables motivates cointegration testing to examine long-run relationships.

### Cointegration Analysis

The Pedroni residual cointegration test examines whether long-run equilibrium relationships exist among the variables. This test accommodates heterogeneous cointegrating vectors across cross-sections and is appropriate for panels with mixed integration orders. Seven test statistics are computed: four within-dimension (panel) statistics and three between-dimension (group) statistics.

### Panel Regression Estimation

Panel Least Squares (PLS) estimation examines the relationships between infrastructure variables and financial development. Four separate models are estimated corresponding to the four infrastructure indicators, each specified as:

$$FDI_{it} = \alpha + \beta_1 ICT_{it} + \beta_2 ICTGE_{it} + \beta_3 POPG_{it} + \varepsilon_{it}$$

Where ICT represents the respective infrastructure variables (MCS, FTS, FBS, or TBS) for country  $i$  at time  $t$ .

The PLS estimator is chosen for its efficiency with correctly specified models and its capacity to handle both cross-sectional and temporal variation. Diagnostic tests for cross-sectional dependence (Breusch-Pagan LM, Pesaran scaled LM, Pesaran CD tests) and residual normality (Jarque-Bera test) confirm model adequacy.

## 5. Results and Discussion

### 5.1 Descriptive Analysis

Table 1 presents descriptive statistics for all variables. The data reveal substantial variation in infrastructure development across SSA. Mobile penetration shows the highest mean (56.52 subscriptions per 100 people) and greatest dispersion (SD: 45.81), reflecting rapid recent expansion alongside persistent gaps. Fixed broadband penetration remains extremely low (mean: 1.18), indicating significant infrastructure deficits for internet-dependent financial services.

**Table 1: Descriptive Statistics**

Variable	Mean	Std. Dev.	Minimum	Maximum
FDI	6.030	5.456	-12.052	14.205
MCS	56.519	45.806	0.024	185.559
FTS	3.786	7.191	0.002	36.885
FBS	1.184	1.086	0.000	3.501
TBS	4.971	7.243	0.217	40.085
ICTGE	4.169	0.620	3.428	5.368
POPG	2.336	0.935	-2.629	5.785

The correlation matrix (Table 2) reveals positive associations between FDI and both MCS ( $r = 0.643$ ) and FBS ( $r = 0.512$ ), while FTS shows near-zero correlation ( $r = -0.018$ ). Notably, MCS and FBS are highly correlated ( $r = 0.732$ ), suggesting infrastructure co-development, while ICTGE correlates negatively with both MCS and FBS, indicating that ICT-exporting countries may not necessarily have superior domestic infrastructure.

**Table 2: Correlation Matrix**

	FDI	MCS	FTS	FBS	TBS	ICTGE	POPG
FDI	1	0.643	-0.018	0.512	0.103	0.023	-0.017
MCS		1	0.375	0.732	0.482	-0.553	-0.317
FTS			1	-0.028	0.989	0.025	-0.658
FBS				1	0.122	-0.728	0
TBS					1	-0.084	-0.653

**5.2 Cointegration Results**

Table 3 presents Pedronicointegration test results. Four of seven statistics strongly reject the null hypothesis of no cointegration at the 1% significance level: Panel PP-Statistic (-25.395,  $p = 0.000$ ), Panel ADF-Statistic (-17.052,  $p = 0.000$ ), Group PP-Statistic (-35.818,  $p = 0.000$ ), and Group ADF-Statistic (-18.721,  $p = 0.000$ ). While the Panel  $v$ -Statistic and Group  $\rho$ -Statistic are insignificant, the dominant pattern confirms long-run equilibrium relationships among financial development and ICT infrastructure variables.

**Table 3: Pedroni Cointegration Test Results**

Test Statistic	Value	p-value	Evidence
Panel v-Statistic	-0.552	0.710	Weak
Panel PP-Statistic	-25.395	0.000	Strong
Panel ADF-Statistic	-17.052	0.000	Strong
Group PP-Statistic	-35.818	0.000	Strong
Group ADF-Statistic	-18.721	0.000	Strong

These results validate the theoretical prediction of long-run relationships and justify proceeding to regression estimation. The existence of cointegration implies that short-term deviations from equilibrium are temporary, with variables adjusting to restore long-run relationships.

### 5.3 Regression Results

Table 4 presents Panel Least Squares estimation results for the four models examining individual and aggregate infrastructure effects.

**Table 4: Panel Regression Results**

Variable	Model 1 (MCS)	Model 2 (FTS)	Model 3 (FBS)	Model 4 (TBS)
Infrastructure	0.093** (0.033)	-0.040 (0.357)	0.375** (0.032)	0.032** (0.043)
ICTGE	0.181 (0.697)	0.150 (0.688)	0.327 (0.549)	0.183 (0.627)
POPG	-0.044 (0.872)	-0.299 (0.368)	-0.097 (0.698)	-0.262 (0.429)
Constant	4.647* (0.058)	7.520*** (0.000)	4.456 (0.092)	7.573*** (0.000)
R-squared	0.442	0.216	0.313	0.520
Adj. R-squared	0.309	0.153	0.202	0.394
F-statistic	0.802*	0.393	0.583	0.291
Durbin-Watson	2.135	2.128	2.126	2.123

\*Note: p-values in parentheses. \*\*\*, \*, \* denote significance at 1%, 5%, and 10% levels respectively.

#### Mobile Telephone Density (Model 1)

Mobile telephone density exhibits a positive and statistically significant coefficient ( $\beta = 0.093$ ,  $p = 0.032$ ), indicating that a 10% increase in mobile

penetration is associated with approximately 0.93% improvement in financial development. This finding aligns with extensive documentation of mobile money's transformative impact across SSA. Mobile networks reduce transaction costs, enable real-time payments, and facilitate savings mechanisms previously inaccessible to large populations. The significance of this effect persists despite controlling for population growth and ICT exports, suggesting mobile telephony's impact operates through financial inclusion channels rather than merely reflecting general technological development.

The model explains 44.2% of variation in financial development (R-squared = 0.442), with diagnostic tests confirming no cross-sectional dependence and normally distributed residuals. The Durbin-Watson statistic (2.135) indicates absence of serial correlation.

#### **Fixed Telephone Density (Model 2)**

Fixed telephone density demonstrates a negative but statistically insignificant coefficient ( $\beta = -0.040$ ,  $p = 0.357$ ). This null finding supports the technological obsolescence hypothesis—fixed-line infrastructure, while historically important, no longer contributes meaningfully to financial development in SSA's mobile-first environment. The negative sign, though insignificant, may reflect resource misallocation where countries maintaining fixed-line investments divert resources from more productive mobile infrastructure.

Model 2 exhibits lower explanatory power (R-squared = 0.216) than other specifications, with the F-statistic indicating overall insignificance ( $p = 0.758$ ). This pattern reinforces the conclusion that fixed-line infrastructure is decoupled from contemporary financial development dynamics in the region.

#### **Fixed Broadband Density (Model 3)**

Fixed broadband density shows a positive and significant coefficient ( $\beta = 0.375$ ,  $p = 0.032$ ), with the largest magnitude among individual infrastructure variables. A 10% increase in broadband penetration associates with 3.75% improvement in financial development. This substantial effect reflects broadband's enabling role for sophisticated financial services—online banking, digital lending platforms, fintech innovation, and institutional connectivity—that deepen financial markets beyond basic inclusion.

The result is notable given SSA's extremely low baseline broadband penetration (mean: 1.18). Even marginal improvements in high-speed internet access generate disproportionate financial development gains, suggesting substantial returns to broadband investment. The model's explanatory power (R-squared = 0.313) exceeds the fixed-line specification but remains below mobile telephony, possibly reflecting broadband's more geographically concentrated impact.

### **Aggregate Infrastructure (Model 4)**

The aggregate telephone and broadband density measure demonstrates positive significance ( $\beta = 0.032$ ,  $p = 0.043$ ), confirming that combined infrastructure development promotes financial development. The coefficient magnitude is modest compared to individual components, likely reflecting measurement aggregation that obscures distinct technology-specific effects. However, the model achieves highest explanatory power (R-squared = 0.520), suggesting the aggregate measure captures complementarities between infrastructure types that individual specifications miss.

### **5.4 Discussion**

These findings generate several important insights for understanding ICT-financial development relationships in SSA.

#### **Technology-Specific Effects**

The divergent results across infrastructure types confirm that not all ICT investments equally promote financial development. Mobile telephony and broadband internet demonstrate significant positive effects, while fixed-line telephony shows no meaningful relationship. This pattern reflects SSA's distinctive technological trajectory, where mobile networks have leapfrogged fixed infrastructure, and broadband represents the frontier for next-generation financial services.

The mobile result validates extensive case study evidence from Kenya, Ghana, and elsewhere documenting mobile money's inclusion impact. However, this study's cross-country panel design establishes that these effects generalize across diverse SSA contexts, not merely exceptional cases. The broadband finding extends this evidence by demonstrating that infrastructure beyond basic mobile connectivity matters for financial development, particularly for market-deepening activities requiring data-intensive services.

#### **Long-Run Dynamics**

The confirmed cointegration relationship carries important policy implications. ICT infrastructure investments generate sustained, permanent improvements in financial development rather than temporary effects. This finding supports strategic, long-term infrastructure planning over short-term interventions. The long-run relationship also suggests that current infrastructure deficits perpetuate financial underdevelopment, creating urgency for accelerated investment.

### **Control Variable Insignificance**

The consistent insignificance of ICT goods exports and population growth across specifications is noteworthy. ICT exports, despite measuring technological capacity, do not directly translate to domestic financial development—possibly because exported ICT products serve foreign rather than domestic markets. Population growth's null effect suggests that demographic expansion alone, without infrastructure and institutional development, fails to stimulate financial deepening.

### **Complementarities and Aggregation**

The aggregate infrastructure model's superior explanatory power, despite modest individual coefficient magnitude, indicates important complementarities between infrastructure types. Mobile and broadband networks likely reinforce each other—mobile providing ubiquitous access, broadband enabling sophisticated back-end services. This synergy implies that integrated infrastructure strategies outperform isolated investments in single technologies.

### **5.5 Robustness Checks**

Diagnostic tests across all models confirm statistical adequacy. Breusch-Pagan LM, Pesaran scaled LM, and Pesaran CD tests uniformly fail to reject null hypotheses of no cross-sectional dependence (all p-values > 0.10), indicating residuals are independent across countries. Jarque-Bera normality tests similarly confirm residual normality (p-values: 0.090, 0.243, 0.218, 0.149 for Models 1-4 respectively). These results support reliable inference from the reported coefficients.

## **6. Conclusion and Policy Implications**

This study examined the impact of telecommunication infrastructure on financial development in Sub-Saharan Africa using panel data from 25 countries over 2000–2024. The analysis generated five principal findings: First, mobile telephone density exerts a significant positive effect on financial development, confirming mobile networks' transformative role in expanding financial access across the region. Second, fixed telephone density demonstrates no significant relationship, indicating technological obsolescence in contemporary financial development contexts. Third, fixed broadband density shows substantial positive effects, highlighting high-speed internet's importance for sophisticated financial services. Fourth, aggregate telecommunications infrastructure positively influences financial development, with complementarities between technologies enhancing

overall impact. Fifth, cointegration tests confirm long-run equilibrium relationships, indicating sustained rather than transient effects.

## **6.2 Policy Implications**

These findings generate specific, actionable policy recommendations:

### **Prioritize Mobile Network Expansion and Quality**

Given mobile telephony's demonstrated financial development impact, policymakers should prioritize universal mobile coverage and service quality improvements. This includes spectrum allocation reforms, infrastructure sharing regulations to reduce costs, and incentives for rural network expansion. Quality dimensions—network reliability, data speeds, and service interoperability—require attention alongside coverage metrics.

### **Accelerate Broadband Infrastructure Investment**

The substantial broadband effect, despite low current penetration, indicates high marginal returns to investment. Governments should implement national broadband strategies, facilitate private sector participation through appropriate regulatory frameworks, and consider public investment in backbone infrastructure where market failures persist. Priority should attach to financial sector connectivity, ensuring banking systems and fintech platforms benefit from reliable high-speed access.

### **Redirect Resources from Fixed-Line Maintenance**

The null fixed-line effect suggests resources currently devoted to maintaining legacy telephone networks could be reallocated more productively. This does not imply immediate fixed-line abandonment—some institutional users may retain specific requirements—but rather strategic assessment of whether maintenance expenditures generate commensurate benefits relative to mobile and broadband alternatives.

### **Promote Technology Integration and Ecosystem Development**

The aggregate infrastructure results highlight complementarities between technologies. Policies should foster integrated ecosystems where mobile access connects to broadband-enabled services, rather than treating infrastructure types in isolation. This includes interoperability standards, unified regulatory approaches, and coordinated infrastructure planning.

### **Support Complementary Investments**

Infrastructure alone is insufficient. Parallel investments in digital literacy, consumer protection frameworks, and financial regulatory capacity are necessary to realize ICT's financial development potential. The long-run cointegration relationship implies sustained commitment across electoral cycles, requiring

institutional mechanisms that protect ICT investment programs from political volatility.

### 6.3 Limitations and Future Research

Several limitations bound this study's conclusions. The Financial Development Index, while comprehensive, may not fully capture informal financial sector dynamics prevalent in SSA. Infrastructure quality dimensions—network reliability, speed, affordability—are imperfectly measured by density indicators. The analysis does not examine distributional effects within countries, potentially obscuring heterogeneous impacts across income groups or geographic areas.

Future research should examine: (1) nonlinear effects and threshold levels where infrastructure transitions from basic access to quality-sensitive impacts; (2) micro-level mechanisms linking infrastructure to household and firm financial behavior; (3) regulatory and institutional conditions that mediate infrastructure effectiveness; and (4) emerging technologies including 5G, satellite internet, and blockchain infrastructure that may reshape the ICT-financial development relationship.

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