Empirical Analysis of the Relationship between Financial Development and ICT Infrastructure Development in Sub-Saharan Africa.

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ABSTRACT

This study investigates the impact of financial development on information and communication technology (ICT) in sub-Saharan Africa. The analysis utilizes a panel dataset comprising 48 countries from the region and employs the bootstrap ordinary least squares (OLS) technique to ensure accurate and robust results. The findings reveal a significant and positive relationship between financial development and ICT indicators. Panel unit root tests indicate a combination of non-stationary behavior and stationarity after differencing the variables. Panel cointegration tests confirm a long-run, continuous cointegration between financial development and ICT infrastructure. The empirical results demonstrate significant cointegration between financial development and various ICT indicators, including internet usage, mobile subscriptions, telephone subscriptions, and fixed broadband subscriptions. The bootstrap OLS method further reveals that financial development has a statistically significant impact on the development of these ICT indicators. The results are robust, as confirmed by the Driscoll-Kraay standard errors regression. Based on these findings, policy recommendations are provided to enhance the synergy between financial development and ICT in sub-Saharan Africa, including promoting financial inclusion, investing in ICT infrastructure, strengthening financial sector regulations, fostering public-private partnerships, investing in digital skills and education, and supporting entrepreneurship and innovation.

Keywords: Financial development, ICT, bootstrap OLS, sub-Saharan Africa

JEL Codes: C33, G3, O3

INTRODUCTION

The impact of financial development on information and communication technology (ICT) development has gained significant attention in recent years, particularly in sub-Saharan Africa (SSA) (Bahrini & Qaffas, 2019). Sub-Saharan Africa, with its diverse range of countries and economies, presents a unique setting to examine the relationship between financial development and ICT development (Roger et al., 2022).

Several studies have explored the link between financial development and ICT infrastructure development in sub-Saharan Africa (Ofori et al., 2022; Shashikant, 2013). According to Sassi and Goaied (2013),

financial development plays an essential role in facilitating ICT development by providing necessary funding and investment opportunities. They argue that a well-developed financial system enables individuals and firms to access the necessary capital to invest in ICT infrastructure and technologies.

On the one hand, a study by Asongu et al. (2020) found a positive relationship between globalization in financial allocation in Africa. Their research, grounded on panel dataset of 48 countries from sub-Saharan African from 1980 to 2008, indicated that improvements in financial development, assessed by indicators such as the depth and efficiency of financial markets, were associated with increased ICT development. They argued that a well-functioning financial sector provides the necessary resources for individuals and businesses to invest in ICT infrastructure and adopt new technologies, thereby promoting ICT development.

Furthermore, financial inclusion has been discovered to be an important aspect of financial development that can impact ICT development. In a comprehensive analysis of 168 countries, including 48 African countries Fanta and Makina (2019) investigated the link between financial inclusion and technology. Their cross-sectional study sheds light on the relationship between these two variables, with a particular focus on internet access and ATMs. The results highlight a statistically significant positive association between financial inclusion and technology usage, emphasizing the importance of access to the internet and the presence of ATMs in promoting financial inclusion.

However, it is important to note that the nexus between financial development and development of ICT in SSA is not universally agreed upon. Some studies have found mixed or inconclusive results. For instance, a study by Asongu and Nwachukwu (2019) investigated the link between financial access and development of ICT among 53 African economies. Their results suggested that the influence of ICT on financial access was conditional on other factors, such as the level of economic development and governance quality. They concluded that the relationship between financial access and ICT was positive and more pronounced in countries with higher levels of economic development and better governance.

The primary objective is to examine the link between financial development and ICT development in SSA. This involves analyzing the statistical association between financial development indicator and indicators of ICT development, such as internet penetration, mobile phone usage, and ICT infrastructure access. This examination is done by employing the bootstrap ordinary least squares (OLS) regression which is known for precise and reliable estimation.

The study on the influence of financial development on ICT development in sub-Saharan Africa holds significant importance for various stakeholders, including policymakers, researchers, and industry practitioners. Understanding the correlation between financial development and ICT development in this region can have several practical implications. First, policymakers can use the results of this study to design and implement policies that aim to enhance financial inclusion, improve the efficiency of financial markets, and provide favorable regulatory environments for the ICT sector. This can lead to more targeted interventions and strategies to leverage the potential of ICT in driving sustainable economic development. Second, understanding the correlation between financial development and ICT development can help investors assess the potential returns and risks associated with investing in ICT projects or ventures. It provides insights into the enabling factors and conditions necessary for successful ICT investments, enabling more informed decision-making regarding resource allocation and investment strategies. Lastly, sub-Saharan Africa has seen significant advancements in mobile and digital technologies, and ICT development has the potential to drive digital transformation in various sectors. Understanding the influence of financial development on ICT development can guide efforts to leverage digital technologies in areas such as e-commerce, digital payments, and e-government services. This can promote inclusive growth, enhance access to essential services, and bridge the digital divide within the region.

The remainder of the study is organized as follows: Section 2 offers a comprehensive review of the previous

literature in the field. Section 3 outlines the data sources and methodology utilized in the study. Section 4 presents the findings and facilitates discussions of the results. Finally, Section 5 concludes the paper and offers policy recommendations based on the research outcomes.

LITERATURE REVIEW

The impact of financial development on ICT development has been a subject of growing interest in the literature. This section presents a comprehensive review of empirical studies that have explored this relationship, highlighting key findings and identifying gaps for further research.

A study conducted by Alshubiri et al. (2019) explored the association between ICT and financial development in the Gulf Cooperation Council (GCC) countries. Fixed effects estimations are employed to investigate this relationship. The findings of the analysis reveal that there is positive statistically significant impact of an increase in fixed broadband on indicators of financial development. This suggests that ICT development, particularly in terms of fixed broadband and internet usage, contributes to the advancement of financial development.

Similarly, Sassi and Goaied (2013) conducted a study to examine the interplay between financial development and ICT diffusion, specifically investigating whether the influence of financial development on economic growth is amplified by a strong ICT infrastructure. Their findings demonstrated a positive and significant relationship between the interaction of ICT penetration and financial development in the context of economic growth. This implies that economies in the MENA region can fully harness the benefits of financial development once a certain threshold of ICT development is attained. Shashikant (2013) examined regional disparities in financial development, ICT diffusion and its relationship with economic growth across a sample of 21 Asian countries. The study employed principal component analysis and Granger causality tests to analyze the data spanning from 1961 to 2012. The findings demonstrate a mutual causality linking financial development and ICT diffusion. The study emphasizes the importance of sufficient availability and integration of financial development and ICT diffusion to achieve higher economic development in the Asian region.

Similarly, Ejemeyovwi et al. (2021) explored the impact of ICT adoption and innovation on financial development in the African context and examined the potential interplay between these two factors. The study utilized Bayesian Vector Auto-Regressive (BVAR) modeling and found that the ICT-innovation interaction positively influences financial development across different sub-regions of the continent.

Furthermore, Asongu and Nwachukwu (2019) conducted a comprehensive analysis to examine the relationship between ICT (internet and mobile penetration) and financial sector development in 53 African nations, with a particular focus on their impact on financial access. The study employed the generalized method of moments (GMM) to capture the dynamic effects of ICT and financial formalization or informalization on financial activity. The findings of the study revealed that the nexus of ICT-financial sector development had distinct effects on financial activity. Although there were negative marginal effects from financial informalization, the overall net effects were positive, highlighting the potential of ICT to enhance financial access in African countries. Kumar (2014) examined the short-run and long-run effects of tourism, ICT, and financial development on economic development. The findings of the study reveal a clear positive relationship that is both statistically significant and meaningful in its impact on tourism in the short-run, while ICT and financial development have substantial positive effects in the long-run.

Also, Asongu et al. (2019) explored the conditional financial development resulting from ICT-driven information sharing in fifty-three African economies. The researchers utilized both contemporary and non-contemporary quantile regression methods in their study and discovered that financial depth and financial activity had positive effects with positive thresholds. The effects of mobile-driven and internet-driven information sharing varied based on financial intermediation efficiency and financial size. Ofori et al.

(2022) investigated the direct and indirect effect of ICT diffusion on inclusive growth in 42 sub-Saharan African countries. The study utilized dynamic system GMM and revealed that the impact of ICT skills, access, and usage are amplified through financial development availability. Zagorchev et al. (2011) examined financial development, technology, growth, and performance in 8 Central and Eastern European countries. The study employed systems of simultaneous equations and GMM methods and found a positive influence of financial development on fixed telephone subscriptions (TEL), while TEL had a weak contribution to financial development.

Empirical studies have provided valuable insights into the influence of ICT infrastructure development on financial development. While some studies confirm a positive relationship, others highlight conditional factors and mixed findings. The role of financial inclusion and financial innovation in promoting ICT development has been acknowledged. Nonetheless, further research is needed to address gaps related to causality, micro-level dynamics, contextual factors, sector-specific analysis, and longitudinal studies. A more comprehensive understanding of this relationship will contribute to informed policy decisions and strategies for harnessing the potential of financial inclusivity and development to drive ICT development.

DATA AND METHODOLOGY

Data source and variables

The study utilizes panel data from 48 sub-Saharan African countries spanning the years 2004 to 2020. Due to data limitations, the aim of this study is primarily on ICT indicators post-2004. The dependent variable of interest is the ICT index (ICT), which serves as a measure of technological development in the region. The main explanatory variable is financial development (FD), specifically capturing a country's domestic credit to the private sector provided by banks. This variable has been extensively studied in the literature and is recognized for its influence on economic growth and development (Anton & Nucu, 2020; Ayadi et al., 2015; Malarvizhi et al., 2019). The significance of ICT in driving economic development is supported by theoretical perspectives presented by (Fong, 2009; James, 2012; Sein et al., 2019; Steinmueller, 2001). These studies highlight the prospective of ICT to enable leapfrogging in the development process. To capture the various aspects of ICT innovation, usage, and penetration, we adopt indicators and proxies utilized in related studies (Gössling, 2021; Odhiambo, 2022; Ofori et al., 2022; Xing, 2018). The following variables are employed to measure ICT usage: mobile phone subscriptions (MOB), fixed telephone subscriptions (TEL), fixed broadband subscriptions (FXBRD), and individuals utilizing the internet (INTERNET).

Additionally, based on the main explanatory variable, two control variables are all added in the analysis. The first control variable is GDP measured in constant 2015 US dollars (GDP), serving as an indicator for economic growth (Dhakal & Lim, 2020; Hussain et al., 2021; Tripathi & Inani, 2020; Usman et al., 2021). The second control variable is bank accounts (BACT), which captures the role of individual financial holdings per 1000 adults and financial inclusion (Emara & El Said, 2021; Van et al., 2021). All data for the variables are obtained from World Development Indicators (WDI) and Global Financial Development (GFD) databases provided by the World Bank (World Bank, 2023).

Based on the empirical literature, it is hypothesized that financial development and the control variables will have a positive influence on all ICT indicators. Therefore, we anticipate observing positive coefficients in our analysis. To handle the problem of heteroskedasticity, all variables are transformed using natural logarithms. Description of these variables and their expected sign are depicted in table 1.

Table 1. Variables description

Code	Variables	Measurement	Expected sign
lnINTERNET	Individuals using the Internet	Percentage of population	+

lnMOBILE	Mobile cellular subscriptions	Subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology	+
lnTEL	Fixed telephone subscriptions	Sum of active number of analogue fixed telephone lines	+
lnFXBRD	Fixed broadband subscriptions	Fixed subscriptions to high-speed access to the public internet	+
lnFD	Domestic credit to private sector by banks	Financial resources provided to the private sector by other depository corporations	+
lnGDP	Economic growth	Constant 2015 US$	+
lnBACT	Bank accounts	Per 1,000 adults	+

Source: Authors' compilations

Model specification

To investigate the influence of financial development on ICT infrastructure development, we employ the bootstrap ordinary least squares (BOLS) method, which is widely recognized for its ability to provide more precise estimates. This approach utilizes a random sampling technique that involves selecting samples with replacement. and falls within the framework of resampling models. Additionally, to ensure the reliability of our findings, we utilize the Driscoll-Kraay standard errors regression estimator with random effects to assess the reliability of the results.

Therefore, to fulfill the main objective of this study, which is to assess the impact of financial development on ICT infrastructure development, we adapt the empirical model proposed by (Khan & Majeed, 2023). Specifically, we specify the ICT variables as a linear function of financial development, while also considering a set of control variables. The model can be expressed in regression form as follows:

$$lnICT_{it} = \beta_0 + \beta_1 lnFD_{it} + \beta_2 lnGDP_{it} + \beta_3 lnBACT_{it} + e_{it} \quad (1)$$

Where the intercept represents an unobserved time-invariant discrete impact, while and represent the effects of FD on ICT, involving the control variables GDP and BACT. The denotes error term. Equation 1 can be expanded to include additional variables relevant to the analysis, such as proxy variables for each specific ICT indicator. We can expand upon the fundamental model presented in Equation 1 by incorporating the following extensions:

$$lnINTERNET_{it} = \beta_0 + \beta_1 lnFD_{it} + \beta_2 lnGDP_{it} + \beta_3 lnBACT_{it} + e_{it} \quad (2)$$

$$lnMOBILE_{it} = \beta_0 + \beta_1 lnFD_{it} + \beta_2 lnGDP_{it} + \beta_3 lnBACT_{it} + e_{it} \quad (3)$$

$$lnTEL_{it} = \beta_0 + \beta_1 lnFD_{it} + \beta_2 lnGDP_{it} + \beta_3 lnBACT_{it} + e_{it} \quad (4)$$

$$lnFXBRD_{it} = \beta_0 + \beta_1 lnFD_{it} + \beta_2 lnGDP_{it} + \beta_3 lnBACT_{it} + e_{it} \quad (5)$$

Where INTERNET represents internet usage, MOBILE represents the number of mobile subscriptions, TEL represents the number of telephone subscriptions, and FXBRD represents the availability of fixed broadband. Additionally, we include FD as an indicator for financial development, which is measured by the domestic credit to the private sector provided by banks. GDP represents economic growth, measured at constant 2015 US dollars, and BACT represents the number of bank accounts per 1,000 adults.

RESULTS AND DISCUSSION

Descriptive results of variables

In Table 2, we present the summary findings of the main variables under investigation. The average regional

Internet usage (INTERNET) stands at 1.771%, with a minimum value of -3.473% and a maximum coefficient of 4.324%. The standard deviation is recorded at 1.418%. Mobile subscriptions (MOBILE) have an average of 14.889%, ranging from a minimum of 8.955% to a maximum of 19.135%. The standard deviation for MOBILE is 1.811%.

For the economic indicators, the average economic growth (GDP) is $23.007 billion, while financial development (FD) is $2.46 billion. The minimum and maximum values for GDP are 19.015% and 26.9568%, respectively, while FD ranges from -5.721 to 4.653. The mean values for fixed telephone subscriptions (TEL) and broadband subscriptions (FXBRD) are 11.2 and 8.911, respectively. TEL ranges from a minimum of 4.653 to a maximum of 14.35, while FXBRD ranges from 0 to -5.721. The variable bank account (BACT) has mean value of 4.977, and standard deviation value, 1.286. The minimum and maximum values are -0.749 and 8.129, respectively.

The pairwise correlations between the variables indicate positive correlations between INTERNET, TEL, and FXBRD. However, TEL shows a negative correlation with FD and BACT, although these correlations are not statistically significant. The variance inflation factor (VIF) values are all below 6, indicating no evidence of multicollinearity between variables.

Table 2. Summary statistics, correlations and multicollinearity analysis

Variables	lnINTERNET	lnMOBILE	lnTEL	lnFXBRD	lnFD	lnGDP	lnBACT
Observations	780	802	761	683	765	789	507
Mean	1.771	14.889	11.2	8.911	2.46	23.007	4.977
Standard Deviation	1.418	1.811	1.534	2.341	1.402	1.477	1.286
Minimum	-3.473	8.955	5.011	0	-5.721	19.015	-0.749
Maximum	4.324	19.135	15.405	14.35	4.653	26.956	8.129
VIF					2.24	5.224	2.154
Correlation matrix							
lnINTERNET	1						
lnMOBILE	0.136**	1					
lnTEL	0.00470	0.527***	1				
lnFXBRD	0.580***	0.640***	0.519***	1			
lnFD	0.558***	-0.0915	0.160**	0.409***	1		
lnGDP	0.0685	0.846***	0.647***	0.529***	-0.142**	1	
lnBACT	0.773***	-0.0375	0.0880	0.438***	0.639***	0.0175	1

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors' compilation

Panel unit root test

In order to ensure the reliability of our findings and examine the relationship between financial development and ICT, we conduct a stationarity test on macroeconomic variables including INTERNET, MOBILE, TEL, FXBRD, FD, GDP, and BACT. The ADF-Fisher Chi-square test and PP-Fisher Chi-square test are utilized for this purpose (Pesaran, 2007; Phillips & Perron, 1988). The findings are displayed in Table 3. The results demonstrate that except for MOBILE, FXBRD, and BACT, the remaining variables exhibit non-stationary behavior based on the Fisher-ADF and Fisher-PP tests, with a significance level of at least 10% when considering trend. MOBILE, FXBRD, FD, and GDP, also, are stationary at the level in both tests without trend, with a significance level of 1%. However, after conducting first difference, all variables become stationary under both tests. This confirms that the variables consist of a combination of level and first

difference, providing a solid foundation for further exploration of cointegration among the variables.

Table 3. Panel unit root test results

	Variables	Fisher-ADF		Fisher-PP	
		Level	First difference	Level	First difference
With trend	lnINTERNET	2.7545	-9.6990***	1.7985	-10.0397***
	lnMOBILE	-1.6298*	-8.3014***	-2.2801**	-8.6257***
	lnTEL	4.1389	-12.4314***	3.7195	-12.9769***
	lnFXBRD	-4.2696***	-12.7746***	-4.6153***	-12.9587***
	lnFD	1.7534	-15.0331***	1.1274	-15.1434***
	lnGDP	3.7116	-6.6064***	3.7191	-6.7707***
	lnBACT	-2.0979**	-17.6063***	-2.7920***	-18.3675***
No trend	lnINTERNET	2.7540	-13.2734***	3.2933	-13.6139***
	lnMOBILE	-30.5657***	-5.4134***	-30.1699***	-5.6765***
	lnTEL	2.5368	-14.9300***	2.0400	-15.1114***
	lnFXBRD	-8.0882***	-14.8093***	-8.6714***	-15.2816***
	lnFD	-2.5813***	-16.4272***	-3.1844***	-16.3462***
	lnGDP	-2.4776***	-7.1025***	-2.3626***	-7.0094***
	lnBACT	0.0773	-18.3467***	-0.3898	-18.6059***

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors' computations

Panel cointegration test

The panel data cointegration analysis is conducted using the technique introduced by (Kao, 1999; Kao & Chiang, 2001). Since INTERNET, MOBILE, TEL, FXBRD, FD, GDP, and BACT are assumed to be non-stationary in the real economy, they are all used in the cointegration test. Although differencing the variables could enhance stability, it may result in the loss of crucial long-run information required for certain analyses. Hence, we employ the stationary findings acquired from the unit root test as the basis for cointegration testing.

Specifically, the study heavily relies on Kao's test. The findings are depicted in Table 4. All statistics for sub-Saharan Africa pass the test at a 5% significance level when INTERNET is considered as the dependent variable, as indicated by the empirical results. Moreover, significant results are obtained for MOBILE, TEL, and FXBRD as dependent variables in four, three, and three tests, respectively. Notably, the Augmented Dickey-Fuller (ADF) test yields significant results for all dependent variables. Hence, it can be inferred that there is persistent and stable long run correlation between financial development and ICT in the SSA region.

Table 4. Kao test for cointegration results

Dependent variables	Test	Statistic	p-value
lnINTERNET	Modified Dickey–Fuller t	2.0811**	0.0187
	Dickey–Fuller t	1.5220**	0.0640
	Augmented Dickey–Fuller t	1.3846**	0.0831
	Unadjusted modified Dickey–Fuller t	1.9699**	0.0244
	Unadjusted Dickey–Fuller t	1.4076**	0.0796

lnMOBILE	Modified Dickey–Fuller t	-4.8504***	0.0000
	Dickey–Fuller t	-5.8230***	0.0000
	Augmented Dickey–Fuller t	-3.8940***	0.0000
	Unadjusted modified Dickey–Fuller t	-0.6118	0.2703
	Unadjusted Dickey–Fuller t	-4.6137***	0.0000
lnTEL	Modified Dickey–Fuller t	3.5705***	0.0002
	Dickey–Fuller t	3.3988***	0.0003
	Augmented Dickey–Fuller t	3.5003***	0.0002
	Unadjusted modified Dickey–Fuller t	0.2330	0.4079
	Unadjusted Dickey–Fuller t	-0.3146	0.3765
lnFXBRD	Modified Dickey–Fuller t	2.6460***	0.0041
	Dickey–Fuller t	1.0074	0.1569
	Augmented Dickey–Fuller t	2.5107***	0.0060
	Unadjusted modified Dickey–Fuller t	-0.8898	0.1868
	Unadjusted Dickey–Fuller t	-2.3209***	0.0101

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Authors' computations

Main results, bootstrap OLS

Table 5 presents the findings obtained using the bootstrap OLS method to analyze the influence of financial development on ICT indicators. In column (1), we observe the estimates for INTERNET determined by financial development (FD), while column (2) displays the estimates for MOBILE determined by FD. Additionally, column (3) and column (4) provide estimates for TEL and FXBRD, respectively, determined by FD.

The results indicate that financial development has an important role in shaping ICT development. In column (1), the coefficient of FD is estimated to be 0.140, which is 5% statistically significant. This suggests that 1% financial development increase, leads to a 0.140% increase in INTERNET usage when other factors are held constant. This finding aligns with previous research conducted by Alshubiri et al. (2019) investigating the nexus between ICT and financial development in the Gulf Cooperation Council economies. Their study reveals significant positive impact of broadband on financial development, indicating that an increase in fixed broadband usage contributes to the advancement of financial services and infrastructure. The results are consistent with previous research conducted by Owusu-Agyei et al. (2020), who also observed positive correlation between internet usage and various indicators of financial development.

Similarly, in column (2), the coefficient of FD is estimated to be 0.223, also at 5% significant level. This implies that 1% financial development increase, is associated with a 0.223% increase in MOBILE subscriptions. This finding aligns with the research conducted by Lenka and Barik (2018), which also revealed statistically positive significant association between the growth of financial inclusion and the expansion of mobile and Internet services.

Furthermore, the coefficients of FD in column (3) and column (4) are 0.804 and 1.475, respectively, both significant at the 1% level. These results indicate that financial development has a statistically positive significant impact on TEL and FXBRD. Specifically, 1% increase in financial development is associated with a 0.804% increase in telephone subscriptions and a 1.475% increase in fixed broadband subscriptions.

These findings are aligned with the results of a study conducted by Alshubiri et al. (2019), which reported that 1% increase in fixed broadband subscriptions is associated with an approximate 2% increase in financial development.

Moreover, the findings show positive correlation between GDP and INTERNET (0.0638) at a significance level of 5%. Similarly, GDP has statistically positive significant impact on MOBILE (1.140), TEL (0.676), and FXBRD (0.900) at a significance level of 1%. Additionally, the variable BACT shows significant positive effect on INTERNET and FXBRD at a significance level of 1%. These findings suggest that economic growth and bank account holdings play an important role in driving ICT development. This finding aligns with the research conducted by Haldar et al. (2023), which concluded that there is a significant positive relationship between using the internet and economic development.

The results of this study offer compelling evidence backing the findings that financial development plays an important role in the advancement of ICT infrastructure. The findings demonstrate a positive and statistically significant influence of financial development on ICT infrastructure development, underscoring its significant contribution in this domain.

Table 5. Bootstrap OLS regression results

	lnINTERNET	lnMOBILE	lnTEL	lnFXBRD
Variables	(1)	(2)	(3)	(4)
lnFD	0.140**	0.223**	0.804***	1.475***
	(0.0647)	(0.0991)	(0.101)	(0.168)
lnGDP	0.0638**	1.140***	0.676***	0.900***
	(0.0310)	(0.0358)	(0.0376)	(0.0497)
lnBACT	0.765***	-0.0745	-0.0842	0.316***
	(0.0358)	(0.0558)	(0.0503)	(0.0787)
Constant	-3.778***	-11.43***	-6.028***	-17.47***
	(0.706)	(0.842)	(0.891)	(1.167)
No. of observations	486	491	463	433
R-squared	0.622	0.695	0.524	0.575
Wald chi^2	1689.06	1118.53	467.82	814.70
Replications	50	50	50	50

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors in parentheses

Source: Authors' computations

Robustness test

To ensure the robustness and credibility of our findings, we conducted a thorough robustness analysis by replacing our primary model with the Driscoll-Kraay standard errors regression estimator with random effects. This approach allows us to examine the relationship between financial development and ICT from a different perspective. The results of this robustness analysis are presented in Table 6, which confirms that financial development has significant positive impact on ICT. Importantly, these robustness findings are consistent with our previous findings in Table 5, reinforcing the notion that a boost in financial development leads to significant advancements in ICT development.

Table 6. Driscoll and Kraay standard errors regression results – Robustness test

	lnINTERNET	lnMOBILE	lnTEL	lnFXBRD
Variables	(1)	(2)	(3)	(4)
lnFD	0.649***	0.720***	0.116*	1.763***
	(0.151)	(0.155)	(0.0633)	(0.333)
lnGDP	0.992***	1.643***	0.103	1.243***
	(0.212)	(0.312)	(0.145)	(0.310)
lnBACT	0.620***	0.338***	0.0320	0.707***
	(0.0893)	(0.0441)	(0.0805)	(0.105)
Constant	-25.69***	-26.40***	8.189**	-28.24***
	(4.368)	(7.819)	(3.032)	(7.742)
No. of observations	486	491	463	433
R-squared	0.3455	0.6040	0.4743	0.5695
Wald chi^2	150.44	392.08	3.39	1995.29
Prob>chi^2	0.0000	0.0000	0.0000	0.0000

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Standard errors in parentheses

Source: Authors' computations

CONCLUSION AND POLICY RECOMMENDATIONS

The current study focuses on investigating the relationship between financial development and ICT in SSA. To ensure the accuracy and reliability of the findings, a dataset comprising 48 countries from the region is utilized. The study employs the bootstrap OLS technique, which is known for its ability to provide precise and robust results. The data covers the period from 2004 to 2020, allowing for a detailed analysis of the financial development-ICT relationship in SSA.

According to the results and findings of our study, we can conclude that there exists a significant and positive nexus between financial development and ICT in the SSA region. The panel unit root tests indicate that the variables considered exhibit a combination of non-stationary behavior and stationarity after conducting first difference. This provides a strong foundation for exploring the cointegration relationship among the variables.

The panel cointegration tests confirm the presence of a long-run, continuous cointegration relationship between financial development and ICT indicators in sub-Saharan Africa. The empirical results reveal significant cointegration among financial development and INTERNET, MOBILE, TEL, and FXBRD. These findings highlight the interdependence and long-term equilibrium among financial development and ICT infrastructure.

Furthermore, employing the bootstrap OLS method, we find that financial development statistically and significantly impacts the development of various ICT indicators. The coefficients of financial development (FD) in the regression models demonstrate positive and significant effects on INTERNET usage, MOBILE subscriptions, telephone subscriptions (TEL), and fixed broadband subscriptions (FXBRD). These results imply that a boost in financial development leads to corresponding increases in ICT usage and infrastructure.

The robustness checks of our results using the Driscoll-Kraay standard errors regression confirms our main results and reaffirms our findings that financial development depicts positive significant impact of ICT infrastructure.

Based on our empirical findings, we provide the following policy recommendations to foster the synergy among financial development and ICT in SSA:

1. Enhance financial inclusion: Policymakers should focus on improving financial services accessibility, particularly in underserved areas. Expanding the reach of banking services and promoting financial literacy can facilitate greater financial development, leading to increased ICT adoption and usage.
2. Promote development and investment in ICT infrastructure: Governments and stakeholders should prioritize investments in ICT infrastructure, including broadband connectivity, mobile networks, and data centers. This will provide a solid foundation for expanding ICT accessibility and usage, enabling broader economic and social development.
3. Strengthen financial sector regulations: To ensure a supportive environment for financial development as well as ICT growth, policymakers should implement robust regulations and supervision in the financial industry. This includes measures to promote financial stability, consumer protection, and cybersecurity, which are critical for fostering trust and confidence in ICT-enabled financial services.
4. Foster public-private partnerships: Collaboration between public and private sectors is crucial for driving financial development and ICT advancements. Governments should actively engage with industry players, encourage innovation, and facilitate public-private partnerships to leverage expertise, resources, and knowledge sharing in promoting both sectors.
5. Invest in digital skillset and education: To fully capitalize on the prospective of ICT, development and investments in digital skillset training and education are essential. Building a skilled workforce with expertise in ICT will ensure the effective utilization and adoption of technology across various sectors, including the financial industry.
6. Support entrepreneurship and innovation: Creating an enabling environment for entrepreneurship and innovation can stimulate the development of ICT-enabled financial services. Policymakers should establish supportive policies, funding mechanisms, and incubation programs to encourage startups and foster a culture of innovation.

By implementing these policy recommendations, sub-Saharan African countries can unlock the synergistic benefits of financial development and ICT, driving economic growth, enhancing financial inclusion, and improving overall societal well-being.

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