

The relevance of institutional quality as a transmission channel for digital financial inclusion: Evidence from African economies and implications for sustainable development

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Article history:

Received: October 30,
2024

1st Revision: March 18,
2025

Accepted: May 20, 2025

JEL classification:

G21
O16
O43
O55

DOI:

[10.14254/jems.2025.10-1.5](https://doi.org/10.14254/jems.2025.10-1.5)

Abstract: *Purpose:* This study examines whether institutional quality is an effective transmission channel between digital financial literacy and financial inclusion in African economies, with implications for sustainable development goals related to poverty reduction and economic inclusion.

Methodology: The research employs principal component analysis to construct a financial inclusion index and applies system Generalized Method of Moments (GMM) estimation techniques to analyze panel data from 41 African economies (7 emerging, 26 frontiers, and 8 fragile) from 2004 to 2022.

Results: Financial inclusion in Africa is more responsive to access indicators (ATMs and internet banking) than penetration and usage indicators. While the direct impacts of digital finance and institutional quality on financial inclusion show ambiguous results, their interaction demonstrates a significant positive effect, indicating that institutional quality successfully moderates digital finance's impact on financial inclusion.

Theoretical Contribution: The study extends existing financial inclusion theory by identifying institutional quality as a critical transmission mechanism that can transform potentially negative effects of digital finance into positive outcomes for financial inclusion in developing economies.

Practical Implications: Findings suggest that African policymakers should prioritize institutional development alongside digital financial education to

effectively leverage digital finance for inclusive growth, supporting sustainable development goals for reducing inequality and promoting economic participation.

Keywords: financial inclusion, digital finance, institutional quality, African economies, GMM

Sustainable Development Goals (SDGs): **SDG 1:** No Poverty; **SDG 8:** Decent Work and Economic Growth; **SDG 9:** Industry, Innovation and Infrastructure; **SDG 10:** Reduced Inequalities

1. Introduction

The use of technology to create and deliver financial services has intensified since the advent of the fourth industrial revolution (4IR), with technology changing the financial landscape globally. While this comes with the prospect of improving financial inclusion, the widespread digital illiteracy, particularly among developing countries, seems to be widening financial exclusion. According to FinMark (2009), as cited in Ajide et al. (2022), there is high financial exclusion in Africa, with most of their population still using informal finance. For instance, Botswana and Mozambique recorded about 41% and 88% financial exclusion, respectively, in 2009 (Ajide et al., 2022). This has been attributed to low bank branches, low mobile phone penetration, and insufficient automated teller machines (ATMs) (Asongu & Asongu, 2018; Beck, Demirguc-Kunt, & Peria, 2007). Andrianaivo and Kpodar (2011) added that bank penetration is lower than 10% in some regions of Africa.

Aside from attempts to address financial exclusion from the supply side of the financial market, recent evidence shows that improving the demand side of the financial market can be helpful (Grohmann & Menkhoff, 2021). With the advent of digital finance, recent studies (Kamble et al., 2024; Amnas et al., 2024; Khan et al., 2022; Widyaningsih et al., 2021; Pazarbasioglu et al., 2020) assert that digital financial literacy will improve financial inclusion. This will reduce poverty and inequality thereby achieving the SDGs 1 and 10. This is imperative for African developing economies given the extreme poverty, hunger and social inequality in the continent (Atukunda et al., 2021). However, the low digital literacy and poor institutional quality among African countries are strong deterrents to these goals (Sam, 2019).

Consequently, many researchers and policymakers have continued to search for optimal strategies to harness the benefits accruable from the digitalization of finance to create an enabling atmosphere for financial inclusion to thrive. This is very paramount to the sustainable development goals especially among regions with low institutional quality. Besides the low digital adaptation in Africa, the poor qualities of institutions in the continent can weaken its impact on financial inclusion even amidst high digital financial literacy. The adverse/negative effect of institutional quality on financial inclusion in studies such as Markjackson & Timipa (2024), Ajide (2017), Kurecic & Kokotovic (2017), and Abu et al. (2015) accentuates this fact. Consequently, recent studies (Ali et al., 2022; Ajide et al., 2022) hinted that the development of institutions is a necessary precondition for financial inclusion to thrive among African economies. This have been slowed down by the structural disconnect between institutions and financial system in most Africa countries, leaving so much to be desired. This has made many studies (Nguyen & Ha, 2021; Yousaf, 2021; Muriu, 2020) to conclude that there is a missing link yet to be explored in the nexus between institutional quality and financial inclusion. This study therefore argues that the multifaceted nature of institutions suggests that they can improve financial inclusion by first stabilizing the digital space. In other words, digital finance can as well promote financial inclusion through institutional quality as a transmission channel. Therefore, part of the focuses of this paper is geared towards achieving the 9th SDGs (industry, innovation and infrastructure) among others

Given this background, this study therefore aims to examine how digital finance drives financial inclusion among African economies. It also aims to ascertain the moderating effect of institutional quality on digital finance in driving financial inclusion. The relevance of this study is anchored on the fact that digital finance and the benefits of SDGs cannot thrive in a financially repressed/excluded region like Africa. Therefore, this study aims to harness the benefits of digital finance in promoting financial inclusion thereby alleviating poverty, inequality and poor growth in Africa. Hence, findings from this will help in achieving the 1st, 8th, 9th and 10th SDGs. The remainder of the paper is structured in four unique sections. The next section reviews literature and identifies gaps in the literature. Section three presents the study's methodology. This includes the scope,

measurements, sources of data, model specification, and estimation technique. The fourth section presents and discusses the results, while the last section is the conclusion and policy implications based on the findings are drawn.

2. Literature review

Empirical literature is replete with studies on the financial inclusion, digital finance, and institutional quality nexus, with many ambiguous conclusions. The inconsistencies in the literature on this subject have led many researchers to continue the search for the missing link. Therefore, for the sake of clarity pointing out what previous studies have done and the gap that remained in the literature, this section is partitioned into three subsections. The first presents and discussed literature on digital finance nexus with financial inclusion, financial inclusion and institutional quality were the focus of the second subsection while the third subsection examined the interplay of institutional quality to the digital finance and inclusion nexus.

2.1. Empirical review on digital finance and financial inclusion nexus

The general findings across many of these studies, particularly those that examined the role of digital finance on financial inclusion, are that digital finance positively impacts financial inclusion. Digital finance makes it easier for individuals to access formal financial services (Amnas et al., 2024). Using the partial least squares structural equation modelling (PLS-SEM) approach in a sample of 608 Fintech users in India, Amnas et al. (2024) observed that psychological factors such as trust and perceived security moderate the usability of digital finance in creating financial inclusion. They further added that adequate regulation is capable of improving this impact. This suggests that digital finance among developing economies requires some kind of transmission channel to impact financial inclusion. However, the static nature of PLS-SEM technique could not examine the dynamism around this nexus.

Hasan et al. (2023) examined the role of digital financial literacy on financial inclusion among women in a sample of 144 countries using data from the World Bank Global FinDex database. Having employed the probit and logit techniques to analyse the data. Their findings were consistent with those of Zaimovic et al. (2025), Adel (2024) and Kamble et al. (2024) who also found that digital financial literacy (measured in terms of ability to make and receive digital payments) positively drives financial inclusion. While these studies explored a wider view of financial inclusion by using four unique indicators, they have two main drawbacks. First, their focus on digital finance as a tool for making and receiving digital payments is minimal, considering the wide range of alternatives for digital finance. Second, using probit, logit, and static models, such as fixed and random effects estimation techniques, is weak in estimating the ever-changing conditions of finance.

Recent studies (Widyaningsih et al., 2021; George & Pathanamthitta, 2020) employed the convenience sampling technique in Indonesia and India to explore the interrelationship between digital financial literacy, and financial inclusion. Having found financial literacy as a necessary precondition for digital finance, which ultimately drives financial inclusion, their findings further suggest that external factors can moderate this relationship. Widyaningsih et al. (2021) claimed that government role and demonetisation are important moderating factors. Their findings were consistent with that of Okello Candiya Bongomin, et al. (2025) that, developed institutions moderate the impact of digital financial literacy on financial inclusion. Ahmad et al. (2019) added that digital finance improves the operation of bank financial institutions, thereby raising people's confidence in financial inclusion. Therefore, as institutions develops, its benefits trickle down to improve banking institutions' performance through digital finance. This ultimately reduces the perceived risk in digital finance, thereby making financial inclusion inevitable. This hypothesis is tested in this study using institutional quality as the mediating factor between digital finance and financial inclusion.

2.2. Empirical review on institutional quality and financial inclusion

Empirical evidence on the role of institutional quality as a transmission channel of digital finance to financial inclusion have not been sufficiently explored in the literature. However, several studies (Markjackson & Timipa, 2024; Ajide et al., 2022; Ali et al., 2022) investigated the direct impact of institutional quality on financial inclusion. The general findings across these studies are inconsistent and often ambiguous. This is because while some (Ajide et al., 2022; Ali et al., 2022; Bongomin et al., 2018; Allen et al., 2016) found that institutional quality positively drives financial institutions, others (Markjackson & Timipa, 2024; Kwenda & Chinoda, 2019) believe that the relationship is adverse. Besides their ambiguous conclusions, their methodological inconsistencies

and lack of consensus on what aspect of an institution is necessary for financial inclusion to thrive have led to a continuous search for an optimal solution regarding methodology and the selection of instruments.

With emphasis among the African economies, developing and emerging economies in Asia, studies such as Markjackson & Timipa (2024) and Muriu (2020) employed the static models of fixed and random effects approaches to examine this nexus among Sub-Saharan African economies. Besides the methodological lapses of investigating a dynamic system like Africa's institutional quality with a static analysis, their results and conclusions were contradictory. This suggests the need to address the potential endogeneity problem of institutional quality using a dynamic approach. According to Lambert and Volpin (2018), institutions are endogenous to development outcomes. It is on this premise that other recent studies (Kamble et al., 2024; Ajide et al., 2022; Nguyen & Ha, 2021; Yousaf, 2021; Kwenda & Chinoda, 2019; Ali et al., 2016) adopted dynamic techniques such as the 2SLS and the generalised method of moments (GMM) to examine this nexus among African and Asian economies. While this technique (particularly the GMM technique) seems to be most suitable to examine the role of institutional quality on financial inclusion, however, its inability to account for country's specific or unique effects and/or possible structural breaks in the model leaves so much to be desired and investigated in this current study.

2.3. The interplay of institutional quality to the digital finance and inclusion nexus

Although there is enormous literature on the nexus between institutional quality and financial inclusion among African economies, the ambiguous findings among these studies and their methodological lapses suggest a missing link. It is on this premise that studies such as Ansari et al. (2024) and Doku et al. (2023) employed the autoregressive distributed lag (ARDL) and the GMM estimation techniques respectively to investigate the moderating effect of institutional quality on the impact of digital finance on financial inclusion. They both found strong evidence to support the role of institutions in driving financial inclusion through digital finance in Pakistan and Sub-Saharan Africa respectively. However, this conclusion is weakened by the presence of slope homogeneity among the economies under investigation because the techniques they employed cannot account for these problem. Consequently, shocks from one region can easily transmit to other regions, particularly among the Sub-Saharan African region and other developing countries like Pakistan. Besides, the ARDL and the GMM estimation techniques do not account for possible structural breaks in a model. Vo (2024) observed that special importance should be given to the specification of models when examining the role of institutional quality on financial inclusion.

The current study therefore aims to fill this gap in the literature by specifying the model with the use of dummy variables to account for the structural break/slope homogeneity problems. Economies with similar characteristics were grouped together. Hence, emerging, frontier and fragile categories were the three groups used in this study and two dummies were employed to see if there are significant heterogeneities in the intercept and slope coefficients of this economies. Moreover, given the dearth of studies on the transmission of institutions to greater financial inclusion through digital finance, this study aims to examine this using the dynamic system GMM and control for possible heterogeneities among the economies with interactive relationships.

3. Methodology

This section comprises two unique estimation techniques used to analyse the data. These techniques are the principal components analysis and the system's generalised method of moments. While the former was employed to generate an index for financial inclusion, the latter was used to estimate the data.

3.1. The Principal Component Analysis (PCA)

The PCA is used to construct an index for financial inclusion (FINC). This is necessary as studies vary on how financial inclusion should be measured. Kamble et al. (2024) used bank account ownership, savings, credit, and insurance services as measures of financial inclusion (FINC). Markjackson & Timipa (2024), Yousaf (2021), and Ajide (2017) employed bank branch networks, ATMs per 1000 persons, and 1000 km² as measures of FINC, Muriu (2020) used depositors with commercial banks per 1,000 adults. According to Demirguc-Kunt et al. (2013) and Allen et al. (2016), FINC is conceptualized by the World Bank in the Global Findex database to be measured with account ownership, savings, frequency of use, and bank charges. While these variables might be appropriate

indicators of FINC, they are not a broad in scope having excluded mobile money and microfinance institutions (Muriu, 2020). This study follows recent studies (Ajide et al., 2022; Nguyen et al., 2021; Ahamed & Mallick, 2019; Kwenda & Chinoda, 2019) to construct an index for FINC using the PCA technique. This technique is preferred over others because it addresses the bias associated with possible correlation among indicators. Consequently, six indicators were employed under three unique penetrations, access, and usage groups. The penetration variables are bank accounts with commercial banks per 100,000 adults and bank concentration, the access indicators are the number of ATMs per 100,000 people and the number of bank branches per 100,000 people. In contrast, the usage indicators are mobile banking/mobile cellular subscription per 100,000 people and credit to private sector to GDP ratio. The index is then normalized by scaling it between zero mean and one standard deviation (0, 1) using the Sere-Ejembi et al. (2014) index normalization formula to avoid potential aggregation distortion that is common with indexes when their means and standard deviations are different, thus:

$$FINC_{it} = \frac{x_{it} - \min x_{it}}{\max(x_{it}) - \min(x_{it})} \quad (1)$$

Where FINC is the generated index of FINC, x_{it} is each observation in the series, while $\min(x)_{it}$ and $\max(x)_{it}$ are the minimum and maximum observations, respectively. Dividing the difference of each indicator with the minimum value by the range of the series gives an index ranging from 0 to 1.

3.2. Estimation technique

The study employs the system GMM estimation technique because of its unique advantages, especially when the cross-sectional unit ($N=41$) exceeds the time observation ($T=19$). Besides, the system GMM corrects the lagged dependent variable's endogenous problem and the institutional quality's endogeneity in development outcome (Lambert & Volpin, 2018). Moreover, the Generalized Method of Moments (GMM) estimation technique eliminates the problem of serial correlation, heteroscedasticity, corrects for unobserved country heterogeneity, omitted variable bias, and measurement error (Caselli et al., 1996, and Bond et al., 2001). The rationale for using the system GMM rather than the difference GMM is that the former is superior, reducing potential bias and imprecision associated with the latter (Arellano and Bover, 1995; Blundell and Bond, 1998). Besides, it uses orthogonal deviation, reducing the loss of observations, especially in an unbalanced panel. The standard model is thus:

$$y_{it} = \beta_{i0} + \beta_{i1}y_{it-1} + \beta_{i2}x_{it} + \delta_{ij}S_{it} + (v_i + \mu_{it}) \quad (2)$$

Note: y_{it} and y_{it-1} are $N \times 1$ and $N \times M$ vectors of the contemporaneous and past values of FINC, respectively. x_{it} and S_{it} are vector of the independent and instrumental variables of order $N \times M$ and $N \times K$ respectively such that S_{it} which is a set of instruments is strictly exogenous {i.e. $E(S' \mu_{it}) = 0$ } variables that must be less than or equal to the number of groups (N). To guarantee the instruments' validity, K must be greater than or equal to M ($K \geq M$). Strictly exogeneity implies that it must be highly correlated with the explanatory variables but orthogonal/uncorrelated with the error term (μ_{it}). The instrumental variables are used as moment conditions to predict the actual values of the explanatory variables due to the presence of endogeneity in the model. For the sake of simplicity and as Blundell & Bond (2023) recommended, the instrumental variables in this study are the first lags of the explanatory variables. This is because they are not correlated with the error term. The coefficients β_{i1} , β_{i2} , and δ_{ij} are $M \times 1$ vectors of the parameters to be estimated on the explanatory and instrumental variables. Finally, v_i and μ_{it} are the country's specific time invariant effect and the unexplained part of the dependent variable, respectively, hence $\mu_{it} \sim IID(0, \sigma_{\mu}^2)$.

The system GMM takes the orthogonal deviation style of differencing; hence, by differencing equation (2), we arrive at the model to be estimated:

$$\Delta y_{it} = \beta_{i0} + \beta_{i1}\Delta y_{it-1} + \beta_{i2}\Delta x_{it} + \delta_{ij}\Delta S_{it} + \Delta \mu_{it} \quad (3)$$

The countries' specific fixed effects do not vary with time; therefore, they disappear after differencing the model. The post estimation tests to be employed to examine the efficiency and the reliability of models are the Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) Sargan/Hansen test of over-identifying restrictions for the overall validity of the instruments and secondly the AR(1) and AR(2) tests of serial correlation. The null hypothesis states that all instruments as a group are exogenous and that the error term μ_{it} of the differenced equation

is not serially correlated, particularly at the second order (AR2), and must not be rejected. Therefore, higher p-values for both tests are desirable.

3.3. Model specification and design

The empirical models are presented as follows:

$$\begin{aligned} \Delta FINC_{it} = & \beta_{i0} + \beta_{i1}\Delta D_{it}^{i1} + \beta_{i2}\Delta D_{it}^{i2} + \beta_{i3}\Delta FINC_{it-1} + \beta_{i4}\Delta DF_{it} + \beta_{i5}\Delta INQ_{it} \\ & + \beta_{i6}\Delta DF_{it} * INQ_{it} + \\ & + \beta_{i7}X_{it} + \lambda_{ij}\Delta d_t + \mu_{it} \end{aligned} \quad (4)$$

The variables remain as defined above. However, the model introduced the independent variables in real terms, a vector of control variables (X ; GDP growth rate, inflation, and lending interest rate), and three dummies including the year dummies. While the group dummy is necessary to account for possible heterogeneities among the emerging, frontier, and fragile economic groups in Africa, the year dummies (d_t) are used to capture the trend of "FINC" over the years. Therefore, the economies' classifications into their emerging, frontier, and fragile groups according to Fitch (2023) and the variables' definitions and measurements are presented in Table 1.1A (See Appendix). Some pre-estimation tests were conducted to explain the uniqueness of the data before estimation. DF_{it} and INQ_{it} are vectors of digital finance variables and institutional qualities respectively for country i in period t . $\beta_{i0} - \beta_{in}$ and λ_{ij} are all the coefficients/parameters to be estimated.

Moreover, using country dummies was necessary to account for fixed country effects since emerging, frontier, and fragile economies were at different stages of development. This heterogeneity addresses the problem of slope homogeneity to an extent since such solution is not inherently entrenched in the GMM estimation technique. The classifications take i_0, i_1 , and $i_2 \in \{e, f, g\}$ for emerging, frontier, and fragile African economies, respectively ($i_0 \neq i_1 \neq i_2$), such that D_{it}^i is a dummy variable taking 1 if the country type belongs to the i category and 0 otherwise. The emerging group (i_0) is the reference category given their relatively developed financial system, while i_1 and i_2 represent frontier and fragile markets, respectively. As the reference group, two dummies for frontier and fragile groups were required to avoid the dummy variable trap. Therefore, in equation (4), for instance, β_{i0} is the intercept (constant term) coefficient of the emerging group, while $(\beta_{i0} + \beta_{i1})$ and $(\beta_{i0} + \beta_{i2})$ are the intercept coefficients for the frontier and fragile groups, respectively. Note that heterogeneities were tested only in the intercepts but not in the slope coefficients for the sake of simplicity. That is, the slope coefficients, instrumental variables, and year dummies are homogeneous across countries. Although this model tested for heterogeneity only in the intercept, it is still unique since it allows us to examine whether the countries, on average and ceteris paribus, report similar averages of FINC over time and allows for comparison. That is, it allows us to directly test for heterogeneity in the intercepts among the three economic groups. Finally, the β_{i6} coefficient was used to examine the main contribution of this study. It tests the hypothesis' to what extent does digital finance drives financial inclusion through institutional quality as the channel.

3.4. Data measurement and sources

Six components were used to construct the FINC index: two each for FINC penetration, access, and usage (See Table 1.1A). They are penetration variables (bank accounts with commercial banks per 100,000 people and bank concentration), the access indicators (the number of ATMs and the number of bank branches each per 100,000 people), and the usage indicators (mobile banking, proxy with mobile cellular subscription and the ratio of credit to private sector to GDP). The independent variables include digital finance, proxy with individuals using the internet, five institutional quality indicators (rule of law, regulatory quality, control of corruption, government effectiveness, and political stability), and three macroeconomic variables (economic growth rate, lending interest rate, and the inflation rate). The sample period is 2004 to 2022 and was sourced from the World Bank and the International Monetary Fund databases. The summary of the variables and countries' classifications (7 emerging, 26 frontiers, and 8 fragile economies) are presented in Table 1.1A in the Appendix.

4. Results and discussion

The analyses began with the discussion of the preliminary results, viz, the descriptive statistics and the correlation matrix, presented in Tables 1 and 2, respectively. Aside from the minimum and maximum values, four main moments were reported in the descriptive statistics. They are the mean,

standard deviation, skewness, and kurtosis. The total observation is 779. The mean of nine (9) out of twelve (12) indicators (including country's dummies) were positive, while three (3) variables reported negative mean values. The mean values of the financial inclusion are 17.1, 63.4 and 19.5 per cents for the emerging, frontier and fragile African economies, respectively. Although the result reveals higher financial inclusion among the frontier and fragile African economies than that among the emerging groups, this could indicate that emerging markets have migrated to a technology-enabled financial solution (financial technology) rather than conventional finance.

The high kurtosis value at 8.052 for emerging economies compared to 1.31 and 3.367 among the frontiers and fragile groups accentuates the fact that there are high tendencies among the emerging group to deviate from the norm. The rest of the variables are homogeneous across the three economic groups. The highest and lowest mean values were recorded for CCrupt and GOE, respectively, whereas the highest standard deviation, at 27.4 percent, was recorded for the inflation rate, suggesting that it could be a primary source of instability in the model. Hence, there might be evidence of outliers in the series. This assertion was supported with a very high maximum value and kurtosis at 557.2 and 249.3, respectively, for the inflation rate. Therefore, except macroeconomic variables (lending interest rate, inflation rate, and growth rate) that reported very high kurtosis values, the rest of the variables report relatively low kurtosis values.

Table 1: Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Financial Inc Index (Finc)	779	.171	.164	0	1	2.159	8.052
Frontier Dummy (DFr)	779	.634	.482	0	1	-.557	1.31
Fragile Dummy (DFg)	779	.195	.397	0	1	1.539	3.367
Digital Finance (DF)	779	19.255	20.63	.155	89.9	1.272	3.761
Lending Int. Rate (LINTR)	779	13.446	11.262	0	131.813	3.282	23.416
Inflation Rate (INF)	779	9.235	27.441	-8.975	557.202	14.323	249.275
Growth Rate (GDPG)	779	4.293	4.708	-20.805	37.999	-.055	12
Control of Crupt. (CCrupt)	779	42.055	21.415	4.369	98.585	.319	2.296
Government Eff. (GE)	779	-.634	.59	-1.756	1.15	.603	2.974
Political Stab. (PS)	779	33.064	22.811	.948	93.75	.553	2.391
Regulatory Quality (RQE)	779	-.577	.566	-2.202	1.197	.283	3.549
Rule of Law (RLaw)	779	-.579	.595	-1.87	1.024	.261	2.683

Source: Estimation

The correlation results in Table 2 show the level of association-ship among the variables and guarantee the absence of multicollinearity among the independent variables. The results reveal strong evidence of multicollinearity among the independent variables. The correlation coefficients between GOE and CCrupt, RLE and CCrupt, RLE and GOE, RQE and GOE, and RLE and RQE were more than 85 percent. These suggest that the variables might have an exact or perfect multicollinearity relationship. Hence, including all these variables in a single model could lead to spurious regression. Consequently, each of the five institutional quality variables used in this study was parsimoniously used once per model.

Table 2: Matrix of correlations

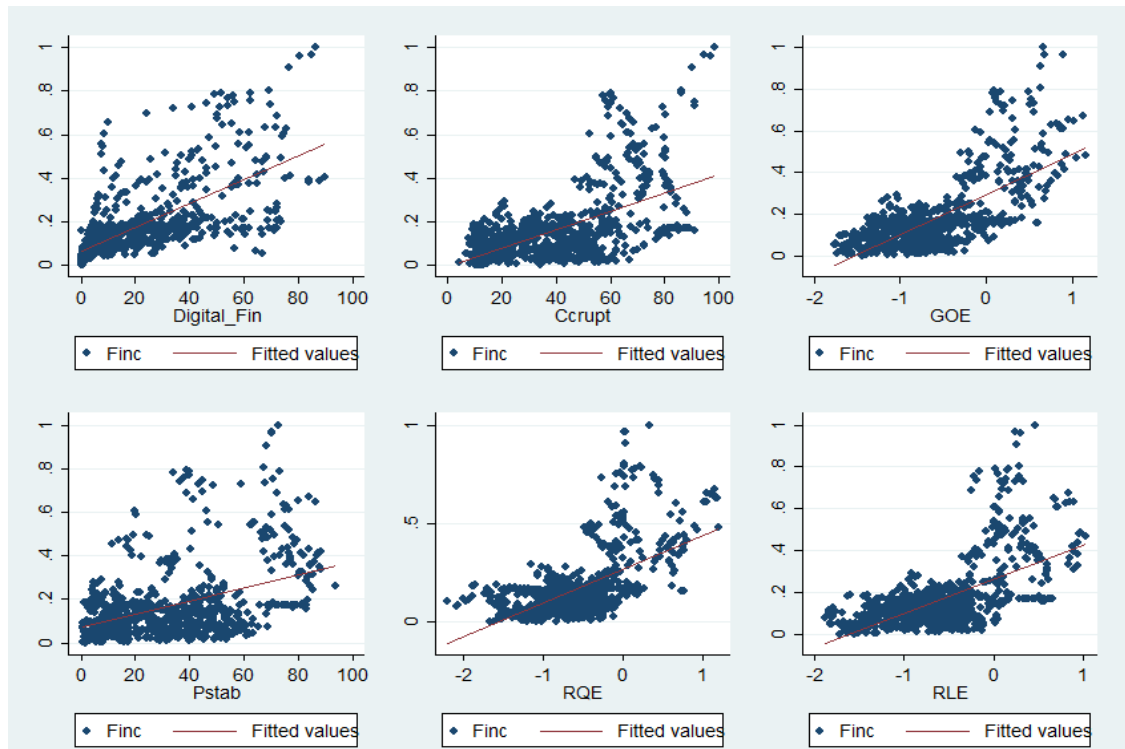
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Finc	1.000									
(2) Digital_Fin	0.687	1.000								
(3) LINTR	-0.188	-0.193	1.000							
(4) INF	-0.059	0.003	0.191	1.000						
(5) GDPG	-0.164	-0.227	0.016	-0.137	1.000					
(6) CCrupt	0.551	0.344	-0.141	-0.140	0.052	1.000				
(7) GOE	0.694	0.436	-0.195	-0.147	0.020	0.875	1.000			
(8) Pstab	0.424	0.221	-0.026	-0.118	0.005	0.712	0.671	1.000		
(9) RQE	0.588	0.286	-0.120	-0.177	0.036	0.801	0.872	0.649	1.000	
(10) RLE	0.595	0.380	-0.117	-0.129	0.012	0.891	0.910	0.741	0.879	1.000

Source: Estimation

The extents and the degrees of the relationships of the variables, particularly with the dependent variable (Finc), are presented in a scatter plot (Figure 1). The first bar demonstrates the degree of the correlation between Finc and digital finance. The plot reveals that the relationship is positive throughout its horizon, stronger at the early stages of development but sparser at the later periods. The degenerating effects could be attributed to the evolving sophisticated nature of digital finance in recent times, which makes it incompatible with users' knowledge in accessing financial

services. The next five bars show the relationship between financial inclusion and the five indicators of institutional quality. The results reveal a robust correlation between Finc and corruption control (Ccrupt), government effectiveness (GOE), Political stability (Pstab), regulatory quality (RQE), and rule of law (RLE), for almost the entire horizon. Moreover, there is evidence of a nonlinear relationship among the indicators being assessed, given the plots convex flow/relationships with Finc to the origin. This suggests that African institutional quality could be unstable but oscillates over time. This is an area for further studies since it is outside the coverage of this study.

Figure 1: Scatter plots of Finc, digital finance, and institutional quality indicators



Source: Estimation

Results of the parsimonious system GMM estimation technique were presented in Table 3. Six (6) unique models were presented and discussed. The first model presents the result of the restricted version of equation (4). It shows how financial inclusion, on average, changes among the three economic groups. Given that the reference economy is the emerging market, the study tested whether the average financial inclusion among the frontier (f) and fragile (g) economies (i.e., $Finc^i = \frac{1}{NT} \sum_{it=1}^T Finc_{it}$ where $i = f, g$) is statistically different from that of the emerging economies. Therefore, β_{i1} and/or $\beta_{i2} = 0$ would indicate homogeneity. Hence, we conclude that the three economic groups report similar averages of financial inclusion.

The restricted model 1 result reveals that frontier and fragile dummies are significant at 1 percent level, so the null hypothesis that $\beta_{i1} = \beta_{i2} = 0$ is rejected. This means that, on average and ceteris paribus, there is a significant difference in the levels of financial inclusion among the three economic groups. Moreover, since β_{i1} and $\beta_{i2} < 0$ whereas β_{i0} is positive, it further suggests that emerging African economies on average report a higher growth rate of financial inclusion at 7.6 percent than frontier African economies at 3.9 percent ($\beta_{i0} + \beta_{i1} = 7.6 + (-3.7)$). Likewise, the emerging and frontier groups report higher growth rates on average when compared to the fragile group at -9.1 percent ($\beta_{i0} + \beta_{i2} = 7.6 + (-16.7)$). This finding supports the sustainable development goal of steady state growth across the various economic groups. This follows prior expectations and empirical evidence (Louis & Chartier, 2017) that emerging African economies have higher financial inclusion levels than other economic groups. This could be attributed to their higher level of financial development, better institutional quality, and a more financially literate populace.

Another main finding of Model 1 is the strong positive significance of the lagged dependent variable at a 1 percent significance level. This implies that Africans' financial inclusion strategy is a dynamically stochastic process. That is, random factors such as environmental, social, economic, financial, demographic, structural and other sustainable indicators drive it. This, and their relevance to sustainable development goals (8) decent work and economic growth, (9) industry, innovation

and infrastructure and (10) to reduce Inequalities justifies their inclusion in the model in assessing the drivers of financial inclusion in Africa.

Models 2–6 are the unrestricted parsimonious versions of equation (4). The models examined the impacts of digital financial literacy and structural quality variables (see Table 1.1A in the Appendix) on financial inclusion. The models (2-6) assumed heterogeneity only in the intercepts, whereas homogeneity is assumed in the slope coefficients. The general findings across the models are consistent with that in model 1 that there are heterogeneities in the intercept coefficients. Again, the lagged dependent variable, and the institutional variables are positively significant, whereas digital finance is negatively significant across the 5 unrestricted models 2-6. The negative impact of digital finance is inconsistent with previous study (Fauziyah, 2024) who found that its post COVID 19 impact on financial inclusion is positive with no clear pre COVID 19 impact, particularly among developing economies. This supports the negative impact of digital finance in this study since a substantial part of the analysis data falls within the pre COVID 19 era. Although a consistent heterogeneity in intercept is still reported as it was in model 1 (i.e., $\beta_{i0} \neq \beta_{i1} \neq \beta_{i2} \neq 0$), however, fragile and frontier markets reported higher averages than the emerging group, particularly in models 2-4. This is an indication that the introduction of digital finance can enable frontier and fragile markets to catch up with their emerging group. However, the switched heterogeneous averages after including the homogeneous slope coefficients (models 2-6), is an indication that the slope coefficients could be heterogeneous across the three groups. It also suggests that its relationship with financial inclusion could be nonlinear. Further studies should explore this gaps.

Table 3: Results of the parsimonious system GMM estimation of equation 4

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	FINC	FINC	FINC	FINC	FINC	FINC
Emerging Intercept	.076*** (.016)	-.158** (.067)	-.043 (.04)	-.078* (.046)	.057*** (.013)	.072*** (.014)
Frontier Intercept/Dummy	-.037** (.015)	.066* (.034)	.12** (.058)	-.058** (.029)	-.055*** (.017)	-.067*** (.017)
Fragile Intercept/Dummy	-.167*** (.03)	.246** (.103)	.293*** (.095)	.312*** (.109)	.066*** (.025)	.018 (.033)
Fin. Inclusion (Finc _{it-1})	.928*** (.016)	1.035*** (.014)	.929*** (.021)	1.073*** (.032)	.985*** (.009)	.984*** (.008)
Digital Fin (DF _{it})		-.005*** (.0001)	-.0002** (.0001)	-.0004*** (.0001)	-.0002*** (.0001)	-.0004*** (.0001)
Control of Crupt. (CCrupt _{it})		.002** (.001)				
Government Eff. (GE _{it})			.104*** (.027)			
Political Stab. (PS _{it})				.002*** (.0005)		
Regulatory Quality (RQE _{it})					.034*** (.008)	
Rule of Law (RLaw _{it})						.026*** (.009)
AR2 Test	.859	.985	.685	.672	.754	.875
Sargan Test	.001	.622	.949	.802	.313	.112
No of Groups	41	41	41	41	41	41
No of Instruments	9	10	10	10	16	18
Year Dummy	No	No	No	No	No	No
Observations	697	697	697	697	697	697

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Estimation

In addition, results from models 2-6 confirm the dynamic stochastic impact of the lagged dependent variables in the restricted version of model 1. This is because of their strong significance across the entire 5 unrestricted models at a 1 percent significance level. This aligns with the findings of Nguyen & Ha (2021) that the lagged dependent variable of financial inclusion positively impacts its current level. Therefore, this also suggests that the adaptive expectation of financial inclusion among individuals in a region informs their current perception. Likewise, the results reveal that institutional variables positively impact financial inclusion. Similar conclusions were reached by Ouechtati (2023), Ali et al. (2022), Nguyen & Ha (2021), Yousaf (2021), Kwenda & Chinoda (2019), and Zins & Weill (2016). The rationale behind this is that as institutions develop, there will be greater financial institutions' transparency with enabling environment for finance to thrive, leading to greater financial development. This finding strengthens the achievement of SDGs numbers 1, 8, 9, 10

and 11. Therefore, corruption control, government effectiveness, political stability, regulatory quality, and rule of law were among the institutional indicators that promote financial inclusion among African economies. Hence, better institutions promote financial inclusion among developing economies (Mbodj & Laye, 2025; Nguyen & Ha, 2021).

On the other hand, studies that found a negative nexus between financial inclusion and institutional quality, especially among African economies (Markjackson & Timipa, 2024; Ajide, 2017; Kurecic & Kokotovic, 2017; Abu et al., 2015) argue that there is a structural disconnect between institutions and the financial system in the continent. This means that institutional quality can impact finance through some means of transmission. Consequently, Amnas et al. (2024) recognized that the moderating impact of digital financial literacy with institutional development leads to better financial inclusion. The negative direct impact of digital finance strongly strengthens this finding. Hence, the study concludes that there might be a high level of digital disconnection and illiteracy among African economies. This calls for a moderating effect to fix this missing link yet to be explored in the literature (Ansari et al., 2024; Nguyen & Ha., 2021; Yousaf, 2021; Muriu, 2020). Consequently, in addition to exploring the direct impacts of digital financial literacy and institutional quality on financial inclusion (models 2-6), this study further examined whether their interaction transmits to better financial inclusion.

Results of the interactive impacts of digital finance and institutional quality on financial inclusion were presented in Table 4, models 7-12. The general findings across these models were consistent with the parsimonious outputs in models 2-6. First, the three African economic groups report heterogeneity intercepts on average during the short run, ceteris paribus. Second, changes in financial inclusion strategy in Africa are dynamically stochastic. Third, digital finance consistently and significantly impacts financial inclusion negatively. While this suggests that households in Africa are digitally illiterate and disconnected, it also implies that digital finance needs a transmission channel to positively drive financial inclusion in Africa. This is consistent with the findings of Pazarbasioglu et al. (2020) who blamed the poor digital finance on low financial literacy.

Table 4: Results of the interactive system GMM estimation of equation 4

	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Dependent Variable	FINC	FINC	FINC	FINC	FINC	FINC
Emerging Intercept (Constant)	.033** (.014)	.046*** (.015)	.115** (.056)	.253*** (.093)	.06*** (.015)	.045*** (.011)
Frontier Intercept/Dummy	-.139*** (.036)	-.023 (.016)	-.268** (.117)	-.53** (.216)	-.036** (.017)	-.034*** (.012)
Fragile Intercept/Dummy	.275*** (.099)	-.114*** (.029)	.337** (.167)	.511** (.258)	-.126*** (.027)	-.068*** (.015)
First Lag of Finc (Fincit-1)	1.171*** (.055)	1.015*** (.016)	1.083*** (.051)	1.086*** (.046)	.995*** (.011)	1.021*** (.01)
Digital Fin. (DFit)	-.004*** (.001)	-.0004*** (.0001)	-.003** (.001)	-.0002* (.0001)	.0003*** (.0001)	-.002*** (.0004)
Digital Fin.*CCrupt (DF*CCit)	.018*** (.004)					.003* (.002)
Digital Fin.*G. Eff. (DF*GEit)		-.001** (.0002)				.000001 (.0002)
Digital Fin.*PS (DF*PSit)			.003** (.001)			.00002*** (.000001)
Digital Fin.*RQE (DF*RQEit)				.042** (.018)		-.0004** (.0002)
Digital Fin.*RLaw (DF*RLawit)					.05*** (.021)	-.001*** (.0002)
Lending Int. Rate (LINTRit)						-.0002*** (.0001)
Inflation Rate (INFit)						.0001 (.00003)
Growth Rate (GDPGIt)						.001* (.0005)
No of Observations	697	697	697	697	697	697
AR2	.891	.965	.876	.569	.991	.720
Sargan Test	.127	.322	.132	.923	.193	.578
No of Group	41	41	41	41	41	41
No of Instruments	11	14	7	10	16	40

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Estimation

Models 7-11 present results of the interaction of digital finance with the five institutional quality variables, each per model. In addition to these, model 12 examined the impact of macroeconomic variables on financial inclusion. The results reveal that, with the exception of model 8 (the interaction between digital finance and government effectiveness (DF*GE)), that reported a negative impact of the interactive term, the rest of the models revealed that institutional quality improves the impact of digital finance on financial inclusion. This is because the magnitudes of their impacts improved significantly compared to those in models 2-6. For instance, although there is still a marginally smaller adverse effect of digital finance on financial inclusion in model 7 (-0.004) compared to that in model 3 (-0.005), its interaction with institutional quality (control of corruption) reveals a marginally higher positive impact. Hence, institutional quality improves the impact of digital finance on financial inclusion and vice versa.

A similar conclusion is reached when digital finance interacts with political stability, regulatory quality, and the rule of law. Therefore, African economies can promote financial inclusion by allowing institutional quality to promote the use of digital finance in accessing financial services. This augments the weaknesses of poor institutions and/or digital financial illiteracy on financial inclusion. Furthermore, this study concludes that the adverse effects of digital disconnection and illiteracy on financial inclusion, that is well pronounced among developing African economies, can be corrected through institutional development.

Again, in addition to the outputs in models 7-11, model 12 includes and examines the roles of control/macroeconomic variables (interest rate, inflation rate, and economic growth rate) on financial inclusion. Besides finding consistent results with those in models 7-11, results in model 12 reveal that including macroeconomic variables weakens the magnitude and the direction of the impact of digital finance interaction with institutional variables on financial inclusion. This can be attributed to a possible multicollinearity problem and the proliferation of the model. Moreover, interest rate (LINTR) and economic growth (GDPG) significantly impact financial inclusion differently. A unit increase in LINTR and GDPG is, on average, and ceteris paribus, associated with -0.02 percent and 0.1 percent changes in financial inclusion during the short run at 5 percent significance levels. This confirms that while high interest rate discourages investment, limit consumption activities, thereby reducing people's financial capacity and participation, a high level of GDPG improves their economic well-being, increases their propensity for process innovations, and widens accessibility and use of financial services. This finding is consistent with those of Nguyen & Ha. (2021), Yousaf (2021), and Muriu (2020).

Finally, the reliability and efficiency of the entire model's parameters were investigated using two different diagnostic tests as proposed by Arellano & Bond (1991). The first is the serial correlation test at second order (AR2) and the Sargan test of over-identifying restrictions, exogeneity, and the overall validity of the instrumental variables. The null hypotheses for both tests state that the error term of the differenced equation is not serially correlated with past error terms, particularly at the second order (AR2), and that the instruments are valid and strictly exogenous; therefore, high p-values for both tests are desirable. The results in Tables 3 and 4 reveal that we cannot reject the null hypotheses since their p-values are all greater than 5 percent. Hence, the model is suitable for policy recommendations.

5. Conclusion and policy recommendation

This study investigated the relevance of institutional quality as a transmission channel between digital financial literacy to financial inclusion among 41 African economies. The study is motivated by the high levels of financial exclusion, poor institutional quality and high digital illiteracy in the continent. This is further strengthened by the ambiguous and inconsistent conclusions in the literature on this nexus, hence, this study argues that institutional quality and digital finance must interplay to promote financial inclusion. Our findings reveal significant heterogeneity in financial inclusion levels across emerging, frontier, and fragile markets, with emerging markets generally demonstrating higher financial inclusion.

The results challenge the conventional understanding that digital finance and institutional quality independently drive financial inclusion. Instead, we find that their interaction creates a powerful synergy that significantly enhances financial inclusion outcomes. Poor institutional quality can negate the potential benefits of digital finance, while strong institutions can transform otherwise ineffective digital finance initiatives into powerful tools for inclusion.

From a practical perspective, our findings suggest that policymakers should adopt a dual approach to financial inclusion strategies:

1. Strengthen institutional frameworks by enhancing rule of law, controlling corruption, improving regulatory quality, ensuring political stability, and increasing government effectiveness

2. Simultaneously promote digital financial literacy while creating supportive institutional environments that build user confidence in digital financial systems
3. Widen accessibility to financial services through financial linearization and reform thereby raising financial confidence among users

From a scientific viewpoint, this research contributes to financial inclusion theory by identifying a critical mechanism through which digital finance operates in developing economies. The transmission effect identified helps explain the previously ambiguous findings in the literature regarding direct impacts of both institutional quality and digital finance on inclusion.

While the study provides valuable insights, limitations include the assumptions of linear relationship, absence of structural breaks in the model and homogeneity in slope coefficients within the different economic groups. Future research should explore a nonlinear relationship among these indicators, check for possible structural breaks and examine deeper heterogeneity even among each economic groups (that is, among emerging, frontier, and fragile economies) in both intercepts and slope coefficients to provide more tailored policy recommendations.

Finally, in terms of sustainable development, findings from this study support several SDGs, particularly SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 10 (Reduced Inequalities). By improving financial inclusion through enhanced institutional frameworks, African economies can accelerate progress toward sustainable and inclusive economic development.

Funding

This research received no external funding.

Conflicts of interest

The author declares no conflict of interest.

Citation information

Okoli, T. T. (2025). The relevance of institutional quality as a transmission channel for digital financial inclusion: Evidence from African economies and implications for sustainable development. *Economics, Management and Sustainability*, 10(1), 74-81. doi:10.14254/jems.2025.10-1.5.

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Appendix

Table 1.1A: Data description, measurement and sources and country classifications

Emerging African Economies	Frontier African Economies	Frontier African Economies	Frontier African Economies	Fragile African Economies
Botswana	Algeria	Ethiopia	Namibia	Congo DR
Egypt	Angola	Gambia	Nigeria	Cote d'Ivoire
Ghana	Benin	Guinea	Niger	Chad
Kenya	Burkina Faso	Madagascar	Rwanda, Seychelles	Gabon
Morocco	Burundi	Malawi	Senegal, Sierra Leone	Mali
Tanzania	Cabo Verde	Mauritania	Tunisia	Sudan
South Africa	Cameroon	Mauritius	Uganda	Togo
	Equatorial Guinea	Mozambique	Zambia	Zimbabwe
Data	Measurements	Source	Expected Sign	
Financial Inclusion Index (Finc.)	This index was generated using PCA with six unique variables grouped under three categories of penetration, access and usage: 1. The Penetration indicators: They include the number of depositors with commercial banks per 1,000 adults and bank concentration. 2. The Access indicators include the number of ATMs per 100,000 people and the number of bank branches per 100,000 people, while; 3. The usage indicators are mobile banking, proxy with mobile cellular subscription per 100,000 people and credit to private sector to GDP ratio.	World bank Database		
Digital Finance (DF)	Internet banking, proxy with individuals using internet to total population ratio	World Bank Database	Positive	
Institutional Quality indicators	These were measured with five (5) variables viz: rule of law, regulatory quality, control of corruption, government effectiveness and political stability	World Bank Database	Positive	
Economic growth rate	Gross domestic product growth rate (GDPG)	World Bank Database	Positive	
Interest rate	Lending interest rate (LINTR)	World Bank Database	Negative	
Inflation rate	Inflation rate (INF)	World Bank Database	Negative	
Frontier Dummy (DFr)	Dummy variable taking 1 if the country is classified as frontier economy and 0, otherwise	Fitch Economy grouping	Negative	
Fragile Dummy (DFg)	Dummy variable taking 1 if the country is classified as fragile economy and 0, otherwise	Fitch Economy grouping	Negative	

Source: Compilation

**Table 1.2A: Result of the principal components/correlation analysis; Number of obs = 760
Number of comp. = 6 Trace = 6; Rotation: (unrotated = principal) Rho = 1.0000**

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.388	2.340	0.565	0.565
Comp2	1.048	0.333	0.175	0.739
Comp3	0.715	0.210	0.119	0.859
Comp4	0.505	0.285	0.084	0.943
Comp5	0.220	0.096	0.037	0.979
Comp6	0.124	.	0.021	1.000

Source: Estimation

Table 1.2B: Principal components (eigenvectors); Sum of squares(column-loading) = 1

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
BAC100	0.398	-0.157	0.669	-0.406	0.304	0.335	0
Bcon	0.000	0.958	0.183	0.112	0.183	0.053	0
ATM	0.511	0.077	0.054	-0.196	-0.101	-0.825	0
BBP100	0.485	0.169	-0.220	-0.134	-0.703	0.419	0
MCS100	0.405	-0.152	0.218	0.873	0.032	0.040	0
DCPS	0.425	0.006	-0.648	-0.064	0.607	0.163	0

Source: Estimation



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