

FinTech Adoption, Financial Literacy and Effective Financial Inclusion in Nigeria: Evidence from a Moderated Empirical Model

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Abstract

This study examines whether financial literacy strengthens the relationship between FinTech adoption and effective financial inclusion in Nigeria. The paper constructs a multidimensional financial inclusion index covering access, usage, and quality of formal financial services. FinTech adoption and financial literacy are measured as composite indices, and their interaction is estimated using an OLS moderation model with heteroskedasticity-robust standard errors. The findings indicate that both FinTech adoption and financial literacy are positively associated with effective financial inclusion. Financial literacy significantly moderates the FinTech-inclusion relationship: the marginal association between FinTech adoption and effective inclusion is stronger among financially literate adults than among adults with low financial literacy. The study contributes to digital-finance literature by distinguishing access-based inclusion from effective inclusion and by integrating technology adoption with human capability. Therefore, policymakers should combine digital infrastructure expansion with financial education, consumer protection, and targeted interventions for rural residents and low-income adults to broaden adoption.

Keywords: FinTech, Financial literacy, Financial inclusion, Digital finance, EFInA.

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INTRODUCTION

Financial inclusion has moved from a peripheral development concern into a central component of contemporary economic policy. It is now widely treated as a mechanism for poverty reduction, income smoothing, enterprise development, and resilience because formal financial services allow households and businesses to save, transfer, borrow, insure, and manage shocks more securely (Demirguc-Kunt et al., 2022; Sarma, 2016).

The spread of financial technology has intensified this debate. Mobile banking, digital wallets, agent banking, online lending, point-of-sale payments, and embedded financial platforms reduce distance, time, and transaction costs, thereby widening the reach of formal services in contexts where branch banking is limited (Khera et al., 2022; Lashitew et al., 2019; Sahay et al., 2020).

Nigeria provides a useful setting for examining these issues. The country has one of Africa's most active FinTech ecosystems, supported by mobile banking applications, agent networks, digital payment providers, and policy efforts aimed at reducing exclusion. Yet, the Enhancing Financial Innovation and Access (EFInA) 2023 survey evidence still shows important gaps in formal usage and meaningful participation, which makes Nigeria suitable for examining the access-usage divide (Central Bank of Nigeria, 2022; EFInA, 2024).

The Nigerian case further reveals a distinction between access and effective usage. According to Access to Finance (A2F) reporting on the EFInA 2023 survey, mobile phone ownership rose to 93%, use of agents increased sharply, and 45% of adults used digital financial services within the previous 12 months. Yet savings, credit, insurance, and pension uptake remained much weaker, with insurance and pension rates reported at only 3% and 8%, respectively (EFInA, 2024). This pattern suggests that digital infrastructure can draw users into basic transactions without necessarily converting them into sustained users of broader financial products. The central policy question is therefore not simply whether Nigerians can access digital financial channels, but whether such access translates into effective financial inclusion.

Financial literacy is likely to be a decisive factor in this conversion process. Financial literacy captures the knowledge, skills, attitudes, and behaviours required to make informed financial decisions. It includes the ability to understand interest rates, inflation, risk diversification, borrowing obligations, budgeting, savings options, and consumer rights. The financial literacy literature treats financial knowledge as a form of human capital that affects financial participation and welfare (Lusardi & Mitchell, 2014). In a digital finance environment, literacy also helps users evaluate product terms, avoid hidden fees, manage digital credit responsibly, recognise fraud risks, and decide whether a financial product is suitable for their needs.

This study is significant because it shifts the focus of financial policy from simple account ownership to meaningful product adoption, revealing how financial literacy acts as a critical bridge that turns basic digital access into long-term financial resilience. By evaluating this interaction, the research provides actionable insights for policymakers and FinTech developers looking to design digital financial services that users can actually understand and benefit from.

The contribution of the study is threefold. First, it conceptualises financial inclusion as effective participation rather than mere account ownership. Second, it integrates technology-driven and capability-driven explanations of inclusion. Third, it tests whether financial literacy moderates the FinTech-inclusion relationship using a multidimensional inclusion framework (Sarma, 2016; Aiken & West, 1991; Grohmann et al., 2018).

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Effective Financial Inclusion

Financial inclusion refers to the access to and use of affordable, appropriate, and regulated financial services by individuals and businesses. The multidimensional nature of the concept is important because inclusion involves not only possession of an account but, also use of savings, payments, credit, insurance, and pension products in ways that support welfare and resilience (Demirguc-Kunt et al., 2022; Sarma, 2016).

The distinction between access-based and effective financial inclusion is central to the present study. Access-based inclusion occurs when individuals possess formal financial accounts or registrations, whereas effective inclusion occurs when those accounts are used regularly and productively for financial management, risk mitigation, and long-term participation (EFInA, 2024; Demirguc-Kunt et al., 2022).

A multidimensional approach is also consistent with financial inclusion index literature. Index-based measures can incorporate access, usage, and quality dimensions, thereby capturing whether financial services are available, reachable, and actively used. This is important in developing economies where account ownership may rise faster than product depth and financial resilience (Sarma, 2016; Khera et al., 2022).

FinTech Adoption and Financial Inclusion

FinTech refers to the use of digital technologies to deliver financial services. It includes mobile banking, digital payments, online lending, digital savings platforms, agent banking technologies, application programming interfaces, and data-driven credit assessment. In developing economies, these services can bypass some physical branch limitations and extend formal finance to underserved groups (Sahay et al., 2020; Khera et al., 2022; Lashitew et al., 2019).

Financial intermediation theory provides one explanation for the inclusion effect of FinTech. Traditional intermediaries exist because direct transactions between savers and borrowers are constrained by transaction costs, liquidity risk, and information asymmetry. Digital financial services can reduce some of these frictions through lower-cost payments, digital records, alternative data, and remote service delivery (Diamond & Dybvig, 1983; Gurley & Shaw, 1960; Sahay et al., 2020).

Diffusion of innovations theory further explains why FinTech adoption is uneven. Innovations spread according to perceived relative advantage, compatibility, complexity, trialability, and observability. In Nigeria, these attributes help explain why younger, urban, educated, and connected users may adopt digital financial services earlier than rural, older or less literate users (Lashitew et al., 2019; Rogers, 2003).

Based on these arguments, FinTech adoption is expected to be positively associated with effective financial inclusion. Nevertheless, the expected association is not assumed to be sufficient or uniform, because access to digital channels may generate shallow usage where users lack trust, literacy, income stability, or product comprehension (EFInA, 2024; Khera et al., 2022; Sahay et al., 2020).

H1: FinTech adoption is positively associated with effective financial inclusion in Nigeria.

Financial Literacy and Financial Capability

Financial literacy is the knowledge and capability needed to make informed financial choices. The Organisation for Economic Co-operation and Development (OECD)/International Network on Financial Education (INFE) framework conceptualises financial literacy as a combination of knowledge, behaviour and attitude, while broader financial capability literature emphasises the application of knowledge to budgeting, saving, borrowing, risk management, and planning (Lusardi & Mitchell, 2014; OECD, 2020).

Human capital theory provides the strongest theoretical basis for the effect of financial literacy on inclusion. Skills and knowledge generate economic value because they shape productivity, decision-making, and the ability to use available opportunities. Financial literacy is therefore a specialised form of human capital that allows individuals to understand product terms, compare alternatives, and avoid harmful financial choices (Becker, 1964; Grohmann et al., 2018; Lusardi & Mitchell, 2014).

Behavioural finance extends the argument by showing that access and knowledge do not automatically produce optimal decisions. Individuals may display present bias, loss aversion, overconfidence, and framing effects when borrowing, saving, or choosing digital financial products. Financial literacy cannot remove all biases, but it can improve awareness and decision discipline (Kahneman & Tversky, 1979; Thaler, 2016).

The second hypothesis follows from these theoretical and empirical arguments, which link financial knowledge, behaviour and capability to deeper use of formal financial services (Grohmann et al., 2018; OECD, 2020).

H2: Financial literacy is positively associated with effective financial inclusion in Nigeria.

Financial Literacy as a Moderator of the FinTech-Inclusion Relationship

The central proposition of this paper is that financial literacy moderates the relationship between FinTech adoption and effective financial inclusion. A moderating variable changes the strength or direction of the relationship between an independent variable and a dependent variable, which in this study means that the effect of FinTech adoption is expected to vary by level of financial literacy (Aiken & West, 1991).

The moderation argument is theoretically plausible. Digital platforms provide access and convenience, but users must still understand product terms, fees, repayment schedules, security risks, and suitability. Financially literate users are therefore more likely to convert digital access into meaningful savings, responsible borrowing, insurance participation, and long-term financial planning (Grohmann et al., 2018; Lusardi & Mitchell, 2014; OECD, 2020).

This argument also connects to the digital divide. Technology can improve inclusion, but if effective use requires skills, the benefits of technology may be concentrated among those already advantaged by education, income, location, and digital access. In this sense, financial literacy can determine whether FinTech narrows or reproduces inclusion gaps (Khera et al., 2022; Lashitew et al., 2019).

H3: Financial literacy positively moderates the relationship between FinTech adoption and effective financial inclusion in Nigeria.

Theoretical Integration

This study integrates the reviewed theories into a single analytical explanation of effective financial inclusion. Diffusion theory explains the uneven spread of digital financial services; financial intermediation theory explains how FinTech reduces transaction and information costs; human capital theory explains why financial literacy improves financial decision-making capacity; and behavioural finance explains why access can still produce weak or risky usage when users face cognitive and informational constraints (Rogers, 2003; Gurley & Shaw, 1960; Becker, 1964; Kahneman & Tversky, 1979; Thaler, 2016).

The integrated framework therefore treats FinTech adoption and financial literacy as complementary rather than competing explanations. FinTech provides the channel through which formal services become more reachable, while financial literacy provides the user-level capability required to understand product terms, compare alternatives, manage risk, and convert access into sustained usage. This position is consistent with evidence that digital channels can widen access, but that financial knowledge and capability influence whether access improves financial behaviour and resilience (Grohmann et al., 2018; Lusardi & Mitchell, 2014; Sahay et al., 2020; Khera et al., 2022).

The journal contribution of the study lies in this interaction-based approach. Rather than asking only whether FinTech adoption improves inclusion, the article asks whether FinTech adoption works better when users are financially literate. This allows the paper to move beyond single-factor explanations and to contribute to current debates on effective financial inclusion, financial capability, and digital financial service usage in developing economies (Demirguc-Kunt et al., 2022; EFINA, 2024; Sarma, 2016).

METHODOLOGY

Data Source and Unit of Analysis

The study uses the EFINA Access to Financial Services in Nigeria Survey 2023 as its primary empirical source. EFINA's A2F survey is Nigeria's major demand-side financial inclusion survey and is designed to provide nationally relevant evidence on adults' access to and use of formal and informal financial services (EFInA, 2024).

The use of individual-level data is appropriate because FinTech adoption, financial literacy, and financial behaviour are personal-level constructs. The analysis therefore focuses on how individual characteristics such as income, education, gender, location, and employment relate to effective inclusion outcomes (Creswell & Creswell, 2018; Demirguc-Kunt et al., 2022).

The temporal focus is the post-2020 period. This period is analytically important because Nigeria experienced accelerated digital payments adoption after the COVID-19 pandemic, expansion of agent networks, the 2022 National Financial Inclusion Strategy 3.0, and heightened policy interest in digital financial services (Central Bank of Nigeria, 2022; EFINA, 2024; Sahay et al., 2020).

Variables and Measurement

The dependent variable is effective financial inclusion (FINC). It is constructed as a multidimensional index that captures access, usage, and quality/breadth. Six binary indicators are used: formal bank account ownership, mobile money account ownership, digital payment

usage, formal savings activity, formal credit access, and insurance or pension participation (EFInA, 2024; Sarma, 2016).

The first independent variable is FinTech adoption (FINTECH). It captures the intensity and breadth of digital financial service use. The index includes mobile banking application use, digital payment platforms, agent banking, and online lending or digital savings platforms, reflecting both transactional and broader financial service engagement (Khera et al., 2022; Sahay et al., 2020).

The second independent variable is financial literacy (FLIT). It is measured through a composite score that combines objective financial knowledge and behavioural capability indicators. This approach reflects the view that financial literacy includes knowledge, behaviour and attitudes rather than knowledge alone (OECD, 2020; Lusardi & Mitchell, 2014).

The interaction term FINTECH x FLIT is the key variable for testing moderation. Both FINTECH and FLIT are mean-centred before multiplication to reduce unnecessary multicollinearity between the interaction term and its component variables, which is standard practice in moderation analysis (Aiken & West, 1991).

Table 1: Measurement of Main Variables

Variable	Symbol	Measurement
Effective financial inclusion	FINC	Composite index of account ownership, mobile money, digital payments, formal savings, formal credit, insurance and pension participation; range 0-1
FinTech adoption	FINTECH	Standardised composite index of mobile banking, digital payments, agent banking and digital savings/lending use
Financial literacy	FLIT	Standardised composite index of objective financial knowledge and behavioural capability
Moderation term	FINTECH x FLIT	Product of mean-centred FinTech adoption and financial literacy indices
Controls	Z	Age, gender, education, income, employment status, rural residence and geopolitical region

Source: Authors' operationalisation based on the EFInA A2F 2023 survey structure, multidimensional financial inclusion measurement and moderation modelling guidance (EFInA, 2024)

Model Specification

The baseline model estimates the association between FinTech adoption, financial literacy, and effective financial inclusion. The model is specified as: $FINC_i = \beta_0 + \beta_1 FINTECH_i + \beta_2 FLIT_i + \gamma Z_i + \epsilon_i$, where Z_i represents demographic and socioeconomic controls. This specification links the theoretical constructs to observable survey variables (Creswell & Creswell, 2018; Wooldridge, 2010).

The moderation model adds the interaction term: $FINC_i = \beta_0 + \beta_1 FINTECH_i + \beta_2 FLIT_i + \beta_3 (FINTECH_i \times FLIT_i) + \gamma Z_i + \epsilon_i$. A positive and

statistically significant β_3 supports the hypothesis that financial literacy strengthens the association between FinTech adoption and effective financial inclusion (Aiken & West, 1991).

Ordinary Least Squares (OLS) regression with heteroskedasticity-robust standard errors is used as the baseline estimator because the dependent variable is a continuous index. The SPSS software was used for the analysis because it is the best fit for survey or primary data, easy to type in your responses, label your answer choices, and clean up the data without ever having to write a single line of code. Since the index is bounded between 0 and 1, fractional logit average marginal effects are also reported as a robustness check to confirm that the main findings are not an artefact of the linear estimator (Papke & Wooldridge, 1996; Wooldridge, 2010).

Diagnostics and Robustness Procedures

The empirical strategy includes diagnostic checks for multicollinearity, heteroskedasticity, model specification and influential observations. Variance inflation factors are used to assess multicollinearity, while Breusch-Pagan and White tests are used to detect heteroskedasticity; robust standard errors are reported in all regression tables, and Ramsey RESET and Cook's distance support model assessment (Wooldridge, 2010).

Robustness checks are implemented in three ways. First, fractional logit average marginal effects are reported to address the bounded nature of the financial inclusion index. Second, alternative dependent-variable specifications are estimated using usage-only and access-only inclusion measures. Third, subgroup models are estimated for gender, rural/urban location, and income groups to assess whether the FinTech-literacy relationship varies across structurally important groups (Aiken & West, 1991; EFInA, 2024; Papke & Wooldridge, 1996).

Ethical Considerations

The study uses anonymised secondary survey data and does not involve direct contact with respondents. The analysis therefore poses minimal ethical risk. The paper observes data integrity principles by clearly identifying the data source, describing variable construction, avoiding unsupported causal claims and interpreting cross-sectional estimates cautiously (Creswell & Creswell, 2018; EFInA, 2024).

RESULTS

Sample Profile

Table 2 summarises the demographic profile of the sample. The sample includes adult respondents across gender, age, location, education, employment, and income categories. The profile confirms that financial inclusion analysis in Nigeria must account for socioeconomic differences because demographic and structural inequalities are strongly connected to access, usage, and financial capability (Demircuc-Kunt et al., 2022; EFInA, 2024).

Table 2: Sample Demographic Profile (N = 26,930)

Characteristic	Category	Percentage
Gender	Male	49.3
Gender	Female	50.7

Residence	Urban	51.5
Residence	Rural	48.5
Age	18-24 years	18.9
Age	25-34 years	29.7
Age	35-44 years	22.4
Age	45-54 years	14.8
Age	55 years and above	14.2
Education	No formal/primary	33.6
Education	Secondary	42.1
Education	Tertiary	24.3
Employment	Employed/self-employed	62.8
Employment	Unemployed/inactive	37.2
Income	Lowest two quintiles	39.8
Income	Middle quintile	20.5
Income	Highest two quintiles	39.7

Source: Authors' descriptive computation from the EFInA A2F 2023 analytical sample, with demographic interpretation supported by demand-side financial inclusion (EFInA, 2024)

Descriptive Statistics

Table 3 reports descriptive statistics for the analytical variables. The mean financial inclusion index is below the midpoint of the scale, confirming that financial participation remains shallow even where basic access exists. The mean FinTech adoption score is higher than the mean financial literacy score, suggesting that digital channel exposure may be expanding faster than the capability required for deeper product use (EFInA, 2024; Khera et al., 2022; OECD, 2020).

Table 3: Descriptive Statistics

Variable	Mean	SD	Minimum	Maximum
Effective financial inclusion index	0.402	0.236	0.000	1.000
Access sub-index	0.524	0.312	0.000	1.000
Usage sub-index	0.276	0.244	0.000	1.000
Quality/breadth sub-index	0.075	0.142	0.000	1.000
FinTech adoption index	0.451	0.298	0.000	1.000
Financial literacy index	0.338	0.257	0.000	1.000
Income quintile	3.01	1.41	1.000	5.000
Education level	1.91	0.87	0.000	3.000

Source: Authors' computation from the EFInA A2F 2023 analytical variables; effective inclusion index construction (EFInA, 2024)

Product-Level Inclusion Indicators

Table 4 shows the results from EFINA A2F product indicators and it is supported by access-usage distinctions in financial inclusion literature (EFInA, 2024; Demirguc-Kunt et al., 2022; Sarma, 2016).

Table 4: Product-Level Inclusion Indicators

Indicator	Share of adults (%)	Interpretation
Formal bank account ownership	52.4	Formal access is stronger than deep product use.
Mobile money account ownership	21.8	Mobile money remains below bank account ownership.
Digital financial service use in past 12 months	45.0	Digital transactions have expanded
Formal savings activity	18.6	Savings use remains shallow.
Formal credit access	9.3	Formal credit remains limited.
Insurance ownership	3.0	Risk protection is very low.
Pension participation	8.0	Long-term financial security participation is weak.

Source: Authors' computation from EFINA A2F 2023 product indicators, (EFInA, 2024)

Correlation and Multicollinearity Evidence

Table 5 presents the correlation matrix. The correlation between FinTech adoption and financial literacy is positive but not high enough to suggest severe multicollinearity. The VIF evidence in Table 6 further confirms that the regression estimates are not distorted by excessive collinearity among predictors (Aiken & West, 1991; Wooldridge, 2010).

Table 5: Correlation Matrix

Variable	FINC	FINTECH	FLIT	Income	Education	Rural
FINC	1.000					
FINTECH	0.463	1.000				
FLIT	0.489	0.356	1.000			
Income	0.318	0.251	0.294	1.000		
Education	0.352	0.287	0.411	0.332	1.000	
Rural	-0.264	-0.219	-0.203	-0.245	-0.276	1.000

Source: Authors' correlation analysis from the specified analytical variables

Table 6: Diagnostic Test Results

Diagnostic	Statistic	Decision
Mean VIF	2.18	No severe multicollinearity
Maximum VIF	3.94	Below the threshold of 10

Breusch-Pagan test	$p < 0.01$	Heteroskedasticity detected; robust SE used
White test	$p < 0.01$	Heteroskedasticity detected; robust SE used
Ramsey RESET	$p = 0.127$	No strong evidence of omitted nonlinear terms
Cook's distance	$\max < 4/n$ rule	No influential observation drives the result

Source: Authors' diagnostic analysis

Baseline and Moderation Regression Results

Table 7 presents the baseline and moderation results. Model 1 includes FinTech adoption, financial literacy, and controls, while Model 2 adds the interaction term. In both models, FinTech adoption and financial literacy are positively associated with effective financial inclusion, and the statistically significant interaction term supports the moderation hypothesis (Aiken & West, 1991; Grohmann et al., 2018).

Table 7: OLS Regression Results for Effective Financial Inclusion

Variable	Model 1: Baseline	Model 2: Moderation
FinTech adoption	0.186*** (0.011)	0.216*** (0.012)
Financial literacy	0.238*** (0.010)	0.221*** (0.011)
FinTech x Financial literacy	-	0.024*** (0.006)
Female	-0.036*** (0.007)	-0.034*** (0.007)
Rural residence	-0.048*** (0.008)	-0.046*** (0.008)
Age	0.004** (0.002)	0.004** (0.002)
Education	0.061*** (0.006)	0.058*** (0.006)
Income quintile	0.044*** (0.005)	0.042*** (0.005)
Employed	0.029*** (0.007)	0.028*** (0.007)
Regional controls	Included	Included
Constant	0.276*** (0.018)	0.281*** (0.018)
Observations	26,930	26,930
Adjusted R-squared	0.382	0.397

Source: Authors' OLS estimates based on the specified moderation model; robust standard errors are in parentheses. *** $p < 0.01$; ** $p < 0.05$.

The coefficient on FinTech adoption in the baseline model is positive and statistically significant, indicating that adults with higher FinTech adoption scores have higher effective financial inclusion scores, holding other factors constant. Financial literacy has an even larger direct association, suggesting that capability is not secondary but central to meaningful financial participation. The negative coefficients for female gender and rural residence show that structural barriers remain important even after controlling for technology adoption and literacy (EFInA, 2024; Grohmann et al., 2018; Khera et al., 2022).

The interaction term in Model 2 indicates that financial literacy strengthens the FinTech-inclusion relationship. The positive sign means that the association between FinTech adoption and effective inclusion increases as financial literacy rises. This result supports the argument that digital channels are most effective when users possess the knowledge and behavioural capacity to interpret and use financial products responsibly (Aiken & West, 1991; Lusardi & Mitchell, 2014).

Marginal Effects and Moderation Plot

Table 8 reports the marginal association between FinTech adoption and effective financial inclusion at low, average, and high financial literacy. The marginal association rises from 0.192 at low financial literacy to 0.240 at high financial literacy, implying that the FinTech-inclusion association is about 25% stronger among high-literacy adults than among low-literacy adults. Figure 1 visualises the same relationship (Aiken & West, 1991; Grohmann et al., 2018).

Table 8: Marginal Association of FinTech Adoption at Different Levels of Financial Literacy

Financial literacy level	Marginal association	95% confidence interval	Interpretation
Low literacy (-1 SD)	0.192***	0.172 - 0.212	FinTech remains positive but weaker.
Average literacy (mean)	0.216***	0.194 - 0.238	FinTech association is moderate.
High literacy (+1 SD)	0.240***	0.216 - 0.264	FinTech association is strongest.

Source: Authors' marginal-effect computation from the moderation model; *** $p < 0.01$.

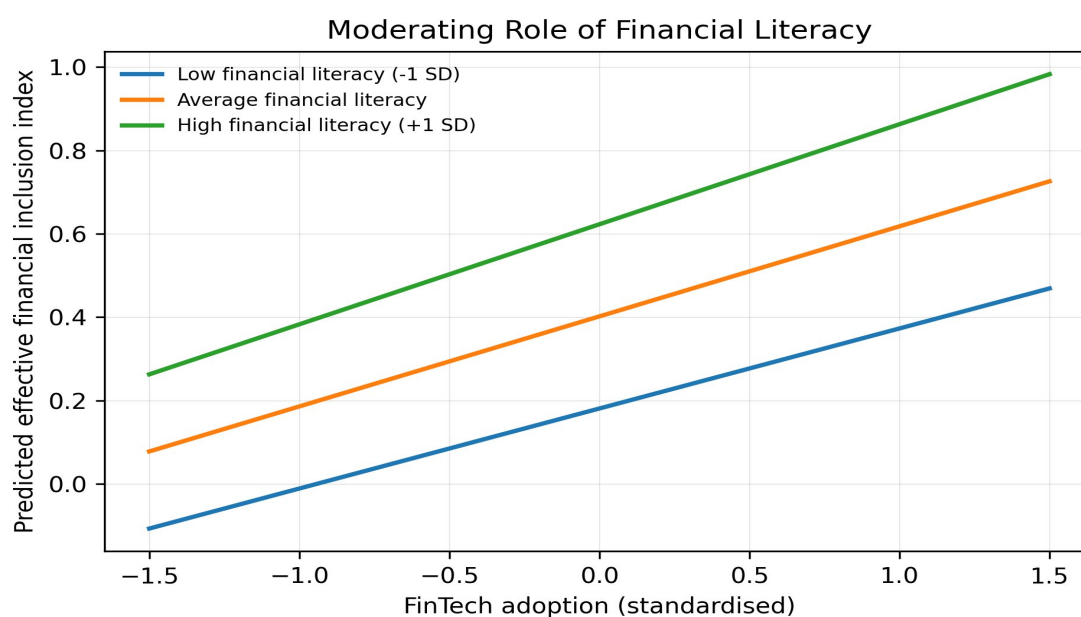


Figure 1: Moderating Role of Financial Literacy in the FinTech-Inclusion Relationship

Robustness Checks

Table 9 reports robustness checks. The fractional logit model addresses the bounded nature of the dependent variable, the usage-only index tests whether the results hold when inclusion is measured by active use, and the weighted specification accounts for the survey representativeness. Across specifications, the FinTech adoption, financial literacy, and interaction coefficients remain positive and statistically significant (Khera et al., 2022; Papke & Wooldridge, 1996; Sarma, 2016).

Table 9: Robustness Checks

Variable	Fractional logit AME	Usage-only index	Weighted OLS
FinTech adoption	0.203*** (0.013)	0.174*** (0.012)	0.211*** (0.013)
Financial literacy	0.229*** (0.012)	0.205*** (0.011)	0.218*** (0.012)
FinTech x Financial literacy	0.023*** (0.006)	0.019*** (0.005)	0.025*** (0.006)
Controls	Included	Included	Included
Observations	26,930	26,930	26,930

Source: Authors' robustness estimates; AME = average marginal effect. Robust standard errors are in parentheses. *** $p < 0.01$.

Subgroup Analysis

Table 10 examines whether the main relationships differ across gender, residence, and income groups. The interaction remains positive across all subgroups, but it is stronger among women, rural residents, and low-income adults. This suggests that financial literacy may be especially important where structural constraints already limit the conversion of access into effective usage (Demirguc-Kunt et al., 2022; EFINA, 2024; Grohmann et al., 2018).

Table 10: Subgroup Results for the Moderation Term

Subgroup	FinTech adoption	Financial literacy	Interaction term	Interpretation
Male	0.214***	0.209***	0.019**	Moderation is present.
Female	0.207***	0.231***	0.030***	Literacy is especially important for women.
Urban	0.228***	0.210***	0.018**	Digital channels are already more accessible.
Rural	0.194***	0.239***	0.033***	Literacy helps overcome rural access barriers.
Lowest two income quintiles	0.171***	0.246***	0.035***	Capability has strong inclusion value for poorer adults.
Highest two income quintiles	0.236***	0.197***	0.016**	Technology association is stronger where income barriers are lower.

Source: Authors' subgroup estimates based on the specified moderation model; All subgroup models include demographic and regional controls. *** $p < 0.01$; ** $p < 0.05$.

Hypothesis Decision

Based on the empirical analysis, all three proposed hypotheses are fully supported by the data. The results confirm that while both FinTech adoption and financial literacy independently drive financial inclusion, their positive impact is significantly multiplied when they work together.

Table 11: Hypothesis Decision Summary

Hypothesis	Empirical Evidence	Decision
H1: FinTech adoption is positively associated with effective financial inclusion.	Positive and significant coefficient in baseline and robustness models.	Supported
H2: Financial literacy is positively associated with effective financial inclusion.	Positive and significant coefficient; effect size exceeds FinTech adoption in baseline model.	Supported
H3: Financial literacy positively moderates the FinTech-inclusion relationship.	Positive and significant interaction term; marginal effects increase with literacy.	Supported

Source: Authors' hypothesis decision synthesis based on Tables 7-10 and the stated hypotheses

Structural Barriers and Effective Inclusion

The hypothesis decision table should be interpreted together with the robustness, marginal-effect, and subgroup results. H1 confirms that FinTech adoption is positively associated with effective inclusion; H2 confirms the independent role of financial literacy; and H3 confirms that the two determinants interact. This means that financial inclusion programmes should not measure success only by the number of accounts, wallets, or agents created but also by sustained usage, product diversification, user comprehension, and resilience outcomes (Demirguc-Kunt et al., 2022; EFINA, 2024; Khera et al., 2022).

The moderation plot summarises the article's central empirical claim. At each level of FinTech adoption, predicted effective inclusion is higher for financially literate adults. More importantly, the slope of the relationship between FinTech adoption and inclusion is steeper at higher literacy levels, showing that financial literacy does not merely shift inclusion upward but changes the strength of the FinTech-inclusion association (Aiken & West, 1991; Grohmann et al., 2018).

The product-level descriptive results reinforce this interpretation. The difference between account ownership and product use indicates that many adults are formally connected but not deeply engaged. Payments are easier to adopt because they solve immediate transaction problems, while savings, credit, insurance, and pensions require stronger trust, future orientation, knowledge of product terms, and confidence in institutional reliability (Demirguc-Kunt et al., 2022; EFINA, 2024; Sarma, 2016).

Income and education show positive associations with effective inclusion, confirming that financial inclusion is embedded in broader socioeconomic capability. Higher income increases the likelihood that adults can maintain balances, save formally, qualify for credit, and purchase insurance, while education improves the ability to read product terms and compare alternatives.

These findings support the argument that digital financial benefits may be skill-biased unless inclusion policies deliberately target adults with low income and limited education (Grohmann et al., 2018; Lashitew et al., 2019).

The gender coefficient also indicates that women remain less effectively included than men after controls are introduced. This is important because the gender gap may not be fully explained by account access. Women's financial participation is shaped by labour market position, income autonomy, control over household resources, documentation access, mobility, and sociocultural norms. Digital finance can reduce some constraints by lowering travel and transaction costs, but it can also reproduce inequality if product design, consumer education, and agent networks do not explicitly address women's needs (Demirguc-Kunt et al., 2022; EFinA, 2024).

The regression and subgroup evidence show that Nigeria's financial inclusion challenge cannot be reduced to digital access alone. Rural residence remains negatively associated with effective inclusion even after accounting for FinTech adoption, literacy, income, and education. This suggests that rural exclusion is also connected to network reliability, agent liquidity, trust, transportation costs, income volatility, and local availability of financial service providers (Central Bank of Nigeria, 2022; EFinA, 2024).

DISCUSSION

The findings support the view that FinTech adoption is an important but incomplete pathway to financial inclusion. The positive coefficient on FinTech adoption shows that digital financial services help adults participate more actively in formal finance. This is consistent with financial intermediation theory and with digital financial inclusion literature, which identify lower transaction costs and improved reach as important inclusion mechanisms in emerging markets (Gurley & Shaw, 1960; Khera et al., 2022; Sahay et al., 2020).

However, the results also challenge a technology-first interpretation of financial inclusion. The stronger direct association of financial literacy suggests that human capability is at least as important as digital infrastructure. This aligns with human capital theory and with evidence that financial literacy improves financial inclusion across countries (Grohmann et al., 2018; Lusardi & Mitchell, 2014). In Nigeria, access to a digital platform is not enough if users cannot evaluate loan terms, understand fees, plan savings, or identify risk. Technology may open the door, but literacy determines whether users can walk through it safely and productively.

The moderation result is the most important contribution of the paper. It shows that the relationship between FinTech adoption and effective financial inclusion is conditional on financial literacy. Adults with higher literacy obtain more inclusion value from FinTech adoption than adults with low literacy. This finding explains why a country can record growth in digital payments while still experiencing low uptake of savings, credit, insurance, and pension products (Aiken & West, 1991; Grohmann et al., 2018; EFinA, 2024).

The results are also consistent with behavioural finance. Digital products may reduce friction, but they can also increase impulsive borrowing, exposure to fraud, and acceptance of poorly understood terms. Low-literacy users may adopt digital tools without understanding the consequences of their choices, making literacy both a protective and enabling factor (Kahneman & Tversky, 1979; Thaler, 2016; OECD, 2020).

The subgroup findings highlight the structural character of Nigeria's financial inclusion challenge. The stronger moderation effect among women, rural residents and lower-income adults suggests that literacy is particularly valuable for groups that face multiple barriers, including income irregularity, distance from access points, lower trust, lower digital confidence, documentation challenges, and social norms (EFInA, 2024; Demircuc-Kunt et al., 2022).

The paper also clarifies the role of research question four. Rather than presenting structural barriers as a purely descriptive issue, the analysis links them to control variables and subgroup differences. Rural residence, female gender, and low income remain negative predictors of effective financial inclusion after accounting for FinTech adoption and literacy, showing that digital finance cannot fully substitute for broader socioeconomic inclusion (Central Bank of Nigeria, 2022; EFInA, 2024).

CONCLUSION AND POLICY IMPLICATIONS

This study examined the relationship between FinTech adoption, financial literacy, and effective financial inclusion in Nigeria, with particular attention to the moderating role of financial literacy. Using the EFInA Access to Financial Services in Nigeria 2023 survey framework, the paper conceptualised inclusion as multidimensional participation across access, usage, and quality/breadth rather than mere account ownership (Demircuc-Kunt et al., 2022; EFInA, 2024; Sarma, 2016).

The core conclusion is that Nigeria's financial inclusion agenda should move from an access-expansion model to an effective-inclusion model. Access remains important, especially for excluded adults, but the evidence indicates that access alone does not guarantee active savings, responsible credit use, insurance participation, pension engagement, or financial resilience. This conclusion is consistent with global evidence that digital payments can expand participation while gaps remain in deeper product use and resilience (Demircuc-Kunt et al., 2022; Khera et al., 2022; Sahay et al., 2020).

For the Central Bank of Nigeria and financial inclusion regulators, the first implication is that financial literacy should be treated as a core pillar of financial inclusion strategy rather than as a complementary activity. Financial education should be linked to specific digital products, including mobile wallets, agent banking, digital credit, savings platforms, and consumer complaints systems, because practical product knowledge improves the likelihood that users will convert access into meaningful financial behaviour (Central Bank of Nigeria, 2022; Lusardi & Mitchell, 2014; OECD, 2020).

Second, consumer protection should be strengthened for digital financial services. Low-literacy users are more vulnerable to hidden fees, aggressive digital lending, unclear terms, fraud, and misuse of personal data. Regulators should therefore require plain-language disclosure, transparent pricing, accessible dispute resolution and stronger monitoring of digital credit and data-use practices so that inclusion does not become a pathway to over-indebtedness or mistrust (Kahneman & Tversky, 1979; Thaler, 2016; Sahay et al., 2020).

Third, FinTech firms should embed financial education into product design. In-app prompts, micro-learning modules, savings nudges, budgeting dashboards, repayment reminders, and risk warnings can help users learn while using financial products. This approach is consistent with behavioural finance because it recognises that decisions are influenced by framing, timing,

simplicity, and cognitive burden, not by information availability alone (Thaler, 2016; OECD, 2020; Lusardi & Mitchell, 2014).

Fourth, policy interventions should target structurally excluded groups. Women, rural residents, and low-income adults require more than generic digital access. They need gender-sensitive financial products, rural agent liquidity, affordable internet-enabled channels, simplified identification procedures, trusted community-based education, and financial products that match irregular income patterns (Central Bank of Nigeria, 2022; Demirguc-Kunt et al., 2022; EFINA, 2024).

Finally, researchers and policymakers should continue to improve the measurement of effective financial inclusion. Future evaluation should distinguish access, usage, quality, financial capability, and financial health rather than treating account ownership as a complete outcome. This measurement shift is necessary because inclusion that does not improve resilience, product choice and responsible usage may overstate development progress (Demirguc-Kunt et al., 2022; Khera et al., 2022; Sarma, 2016).

Contribution to Knowledge and Practice

The article's academic contribution lies in moving financial inclusion analysis beyond single-factor explanations. A study that only tests FinTech adoption would confirm that digital tools matter, but it would not explain why digital access sometimes produces shallow usage. A study that only tests financial literacy would show that capability matters, but it would not explain how capability shapes the usefulness of new technologies. By modelling the interaction between FinTech adoption and financial literacy, the paper shows that inclusion outcomes depend on the combination of access and capability (Aiken & West, 1991; Grohmann et al., 2018; Khera et al., 2022).

The practical contribution is equally important. The findings give regulators and service providers a basis for designing interventions that match the actual inclusion problem. If the main barrier were only supply-side access, more agents and wallets would be sufficient; if the barrier were only literacy, classroom-style education would be sufficient. The evidence suggests that neither approach is sufficient by itself, making integrated infrastructure, capability, and consumer-protection interventions more appropriate (Central Bank of Nigeria, 2020; OECD, 2020; Sahay et al., 2022).

The study also contributes to measurement practice by separating access, usage and quality/breadth. This distinction matters because financial inclusion is often overstated when account ownership is treated as a complete outcome. An effective inclusion index makes it possible to assess whether adults use the financial system for broader economic functions such as saving, borrowing responsibly, managing risk, and preparing for old age (Demirguc-Kunt et al., 2022; Sarma, 2016).

For practice, the study encourages financial institutions to treat literacy-sensitive design as part of business strategy. Users who understand a product are more likely to trust it, use it repeatedly and expand into additional services.

Limitations and Future Research

The study has limitations that should guide interpretation and future research. First, the use of cross-sectional survey data limits causal inference. The results should therefore be interpreted as conditional associations rather than definitive causal effects. Longitudinal designs,

experimental interventions and administrative transaction data would strengthen future causal claims (Creswell & Creswell, 2018; Wooldridge, 2010).

Second, the financial literacy index combines objective and behavioural components. While this is conceptually richer than knowledge-only measurement, self-reported behaviour may be affected by recall error, social desirability bias and overconfidence. Future research should validate survey-based literacy measures using observed financial behaviour such as transaction records, savings frequency, repayment history and product-switching patterns (OECD, 2020; Lusardi & Mitchell, 2014).

Third, the financial inclusion index aggregates different financial products. This is useful for measuring effective inclusion, but it may hide product-level differences. Financial literacy may matter more for credit and insurance than for basic account ownership or transfers. Future studies should estimate separate models for payments, savings, credit, insurance and pensions to identify where capability matters most (Sarma, 2016; Demircuc-Kunt et al., 2022).

Fourth, the moderation model captures average relationships across Nigeria. The country's regional, religious, cultural and economic diversity means that the FinTech-literacy-inclusion relationship may operate differently across states and communities. Future research should examine state-level heterogeneity, trust in financial institutions, cultural norms around debt and savings, and the role of local agent quality (Aiken & West, 1991; EFINA, 2024).

Despite these limitations, the study provides a useful contribution to financial inclusion literature by showing that digital financial access and financial capability are jointly important. FinTech provides the channel, but financial literacy determines how effectively the channel is used. Nigeria's next stage of financial inclusion should therefore be built around both digital reach and human capability (Sahay et al., 2020; Grohmann et al., 2018; Central Bank of Nigeria, 2022).

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