WILL IMPROVED FINANCIAL AND DIGITAL LITERACY INCREASE FINANCIAL INCLUSION FOR ALL?

EVIDENCE FROM SUB-SAHARAN AFRICA.

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Working Paper 085-2026

CONSORTIUM POUR LA RECHERCHE ÉCONOMIQUE EN AFRIQUE

Bringing Rigour and Evidence to Economic Policy Making in Africa

Will Improved Financial and Digital Literacy Increase Financial Inclusion For All? Evidence From Sub-Saharan Africa.

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AERC Research Paper 085-2026
African Economic Research Consortium,
Nairobi August 2026

Disclaimer: The findings, opinions and recommendations are, those of the author, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium

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Abstract

Despite rapid growth in digital financial services (DFS) supply, adoption across sub-Saharan Africa (SSA) remains low and unequal by gender and location. While existing research predominantly attributes this to demographic and socioeconomic factors, this paper proposes a complementary explanation: that deficits in digital literacy (DL) and financial literacy (FL) represent independent and underappreciated barriers to digital financial inclusion (DFI). Using data from the Financial Inclusion Insights (FII) Survey across Kenya, Nigeria, Tanzania, and Uganda, and employing two-stage least squares regression, dominance analysis, interaction analysis, and Blinder-Oaxaca decomposition, the study tests whether DL and FL independently drive DFI, whether their effects are complementary, and whether these effects extend beyond already-advantaged groups to women and rural dwellers. Three findings emerge. First, both DL and FL causally drive DFI beyond economic circumstances. DL's effect is five times larger than FL's (4.2 percentage points vs 22 percentage points), accounting for over 80 percent of explained DFI variance, with their joint effect exceeding individual contributions. Second, literacy effects are not concentrated among urban males: DL benefits women more than men (23.5 vs 21.4 percentage points), with the strongest joint effects among rural and female populations. Third, equalising DL endowments by gender would close 77 percent of the DFI gender gap; equalising by location would close 63 percent exceeding any other single factor. These findings reframe the policy debate: digital skills investment targeting women and rural communities is the most direct lever for inclusive DFI expansion in SSA.

1. Introduction

Over the last two decades, the sub-Saharan Africa (SSA) region has witnessed significant growth in the supply of digital financial services (DFS), yet overall adoption remains lower than in most other regions. For instance, according to the World Bank's Global Findex database, only 20% of adults in SSA made digital merchant payments in 2024, compared to the global low- and middle-income economy average of 42%, and as high as 80% in East Asia and the Pacific. Furthermore, DFS adoption is deeply unequal: the gender gap in DFI account ownership ranges from 2 percentage points in Kenya to 51 percentage points in Nigeria. Rural populations participate at rates roughly half those of urban dwellers. This disconnect between supply and inclusive adoption raises a fundamental question: *why, despite cheaper and more accessible DFS than ever before, do so many remain excluded, and why does adoption remain so unequal across gender and location?*

A growing body of research has sought to answer this question by focusing predominantly on demographic and socioeconomic factors, including income levels and wealth, education and age, geographic location and infrastructure access, and gender related social norms and documentation barriers (Demirgüç-Kunt et al., 2018; Zins & Weill, 2016; Agur et al., 2020; Adegbite & Machethe, 2020). While these contributions are valuable, they implicitly frame inclusion as a supply side problem which can only be resolved through expansion in access and reducing economic costs. The current study proposes a complementary explanation: that DFS adoption is also meaningfully shaped by individual level cognitive capacities, specifically digital literacy (DL) and financial literacy (FL), and that deficits in these capacities represent an independent and underappreciated barrier to inclusion. This reframing has direct policy implications: if knowledge and skills and not just access and economic need drive adoption, then the policy toolkit must expand beyond infrastructure and cost reduction to encompass targeted literacy interventions.

Building on a nascent empirical literature examining the effects of DL and FL and digitial financial inclusion (DFI) (Yang, Wu & Huang, 2023; Prete, 2022; Seldal & Nyhus, 2022; Pratiwi & Saefullah, 2022; Kass-Hanna et al., 2022; Tony & Kavitha, 2020; Morgan & Trinh, 2019; Kiconco, Rooks, Solano, & Matzat, 2019), this study advances beyond existing work around three core hypotheses. First, whereas prior studies have examined DL and FL in isolation, we include both within a single analytical framework and hypothesize that each independently and positively drives DFI. Second, we hypothesize that DL and FL are complementary and that their combined effect on DFI exceeds the sum of their individual contributions, such that interventions targeting both simultaneously are more impactful than those targeting either alone. Third, and most critically, we examine whether the benefits of DL and FL are confined to already-advantaged groups. A natural concern is that literacy effects only matter for those who are most predisposed to adopt DFS regardless, typically men and urban dwellers. If so, their policy value would be limited. We directly test this and the results have important implications for how policymakers should think about targeted literacy interventions as a lever for closing gender and locational gaps in DFI.

To address these objectives, we utilize data from the fifth wave of the Financial Inclusion Insights (FII) Survey across four SSA countries: Kenya, Nigeria, Tanzania, and Uganda. We employ two-stage least squares (2SLS) regression with instrumental variables to address endogeneity, dominance analysis to assess the relative importance of DL and FL, interaction analysis to test for complementarity, sub-sample regressions to assess heterogeneity across gender and location, and Blinder-Oaxaca decomposition to quantify the contributions of DL and FL to observed inclusion gaps. As a preview of the findings, both DL and FL independently and positively influence DFI, with DL exhibiting a larger direct effect. DL proves particularly impactful among women and rural dwellers, suggesting it plays a disproportionate role in bridging existing inclusion gaps. The interaction analysis confirms that DL and FL are complementary, and the decomposition results indicate that equalizing DL and FL across gender and location could eliminate up to 77% of observed inequalities in DFI.

The rest of the study is organised as follows. Section 2 covers some stylized facts about DL and FL in the SSA region including some empirical works as well as theoretical motivations of the study. In Section 3, issues relating to datasets, definitions and measurement of key variables, and empirical estimation strategy are discussed. The final two sections (Sections 4 and 5) contain the discussed results and conclusions.

2. Literature review

2.1. Some stylised facts on digital financial inclusion, digital literacy, and financial literacy in the SSA region

Our empirical evidence for the SSA region is relevant given recent and historic trends in DL, FL and DFI. According to S&P's Global Financial Literacy Survey, SSA countries scored the worst in terms of FL in the world, with most countries in the region having FL lower than 40 percent (Klapper, Lusardi, & Van Oudheusden, 2015). Furthermore, there are also significant variations in FL levels in and among countries in the region. For instance, more than 50 percent of individuals in Kenya are financially literate as against 28 percent in Nigeria. Men also have disproportionately higher levels of FL than women. In Kenya, the gender gap is 7 percent while that for Nigeria is 9 percent (InterMedia, 2017). According to Lusardi and Mitchell (2014), women are also less likely to provide correct answers to the FL questions and more likely to indicate that they "don't know" the answer. Likewise, urban dwellers in many countries in the region also have higher FL rates relative to rural dwellers. In Kenya, the location gap in FL is around 6 percent while that in Nigeria is 8 percent. Although statistics on DL rates in the region are limited, the Financial Insight Inclusion survey (2017) which covers four countries in the region namely Kenya, Nigeria, Uganda and Tanzania provide some evidence on the extent of DL. For instance, only 16 percent of the population in the four countries used smartphones. Seventy-eight (78) percent of the population are non-internet users and close to 75 percent lack the requisite skills to perform a financial transaction using a digital device. Similar to FL, there are also marked gender, income and locational gaps in DL levels in the region. Whereas in Kenya close to 30 percent of the population own smart phones, the case in Uganda is just 11 percent (Lyons, Kass-Hanna, & Liu, 2022).

When it comes to DFI, the SSA region has experienced significant expansion in its supply and shows no indications of abating. The region's rise in DFS is linked to two major sources: mobile network operators (MNOs) and the traditional banking system (GSMA, 2020). MNOs in the SSA area have taken advantage of extensive mobile phone and network penetration to offer financial services via mobile phones, dubbed "Mobile Money service" (Rouse, 2017). As of 2021, over 33 percent of the adult population in the SSA region own a mobile money account, which is far higher than the global average (10 percent). Twenty-three (23) percent of formal account owners also own debit cards. Also, usage has remained low in many countries within the region. For instance, the average use of digital payments in the region is approximately 34 percent which is far below the world average of 45 percent (Chinoda, & Kapingura, 2023). Approximately 25 percent of adults in SSA indicated they saved formally through a mobile money account or financial institution in 2021, compared with 15 percent of adults in 2017 (Demirgüç-Kunt et al., 2020). Also, 50 percent of the population in the region either sent or received remittances through a mobile money account.

Apart from having low DFI relative to other regions, SSA is also noted as one of the regions with the highest DFI gaps, both within and across countries. For example, in terms of DFI by account ownership, while the gender gap persists in Ghana and Kenya at 10.0 percentage points and 2.0 percentage points respectively, it is 51.0 percentage points and 15.0 percentage points in Nigeria and Senegal respectively as of 2021 (Naji, 2021). By usage, the DFI gender gap in Ghana and Kenya are 10.0 and 7.0 percentage points respectively, but are 10 percentage points and 13.0 percentage points in Nigeria and Senegal (Naji, 2021). These pieces of evidence suggest that the DFI gender and location gaps are serious issues in the region necessitating ardent research to advance our knowledge and understanding of what is contributing to such gaps.

2.2. Theoretical and Empirical review

The study is underpinned by the technology acceptance model (TAM), which posits that the adoption of technology is based mainly on the perception of how easy and useful technology is to its consumers (Marikyan & Papagiannidis, 2022). Several researchers have assessed how other external factors can influence DFI adoption through their influence on perceived usefulness and perceived ease of use. For instance, studies have explored the role of individual characteristics, such as age, gender, and experience, in shaping individuals' perceptions of technology. Research has shown that younger individuals tend to have a more positive attitude towards technology and perceive it as easier to use (Venkatesh, Thong, & Xu, 2012).). Gender differences have also been observed, with some studies indicating that males have a higher inclination to adopt new technologies compared to females (Lian, & Yen, 2014).). Additionally, prior experience with similar technologies or related tasks can positively influence individuals' perceptions of technology ease of use and usefulness (Davis, 1989).

In this study, we hypothesize that DL and FL can also impact DFI given their influence on perceived ease of use and perceived usefulness. Prior studies have shown that financial literacy tends to help consumers understand the potential advantages and benefits to be derived from using financial services (Klapper, Lusardi, & Panos, 2013). In addition, FL can empower consumers to make rational decisions about DFS options that best fit their needs given the fees, and the security measures implemented by the service providers. Hence, the higher the FL level, the better consumers can assess the usefulness of digital financial products and make informed decisions concerning their use (OECD/INFE, 2015). On the other hand, higher levels of DL can reduce the complexities associated with DFS, thereby positively influencing the perceived ease of use (Mulyono, 2023). Again, higher DL can help consumers overcome the inertia to adopting and the perceived risk associated with DFS (Luthfia, Wibowo, Widyakusumastuti, & Angeline, 2021). Higher DL levels can result in users taking advantage of all features and capabilities offered by DFS which has the potential of positively enhancing user experience.

2.3. Financial literacy, digital literacy, and digital financial services

Some empirical studies have explored the effect of FL and DL on DFI, as well as the gender and locational inequalities associated with it. For instance, using a structural equation modelling approach, Shen, Hu, and Hueng (2018) examined the effect of financial literacy on digital product usage in China. The study reported a positive association between financial literacy and digital product usage. Similarly, Yang, Wu, and Huang (2023) examined how financial literacy impacts the demand for financial services in China. The study showed that a low level of financial literacy accounted for the low adoption and use of digital financial services in China. Morgan and Trinh (2019) also assessed the effect of financial literacy on digital financial products in Cambodia and Viet Nam. However, this study was restricted to awareness of digital financial services. In Africa, Matita, and Chauma (2020) studied the effect of financial literacy on mobile money service use in Malawi. The study used a series of questions on division, inflation, compound interest calculation, absolute/percent discount, risk, simple interest calculation and risk diversion to measure the financial literacy level of respondents. The study found a positive correlation between financial literacy and the use of mobile money services in Malawi. A few studies have combined both digital and financial literacy, termed digital financial literacy. This

includes the study by Tony and Kavitha (2020) that examined the effect of digital financial literacy on DFI in China. The study was based on primary data and adopted the structural equation approach. From the findings, digital financial literacy has a positive effect on digital inclusion. Prete (2022) also assessed the effect of DL and FL on digital payment use and financial decision-making in OECD countries. She observed that irrespective of the level of FL, the use of digital payment platforms is positively associated with DL. Also, personal financial decision-making is influenced by FL no matter the digital proficiency level. Kass-Hanna et al., (2022) assessed how FL and DL can help improve financial resilience in SSA and Asia. They revealed that in building strong financial resilience, FL and DL are prominent factors to consider.

In examining the factors that influence women's retirement planning and hence their financial inclusion, Lusardi and Mitchell (2009) found that financial illiteracy was a major driver of poor retirement planning. Yang et al. (2023) also revealed that women in the US, Germany, Switzerland, China and the Netherlands, especially among the less educated tend to be financially illiterate, which they argued affects their financial inclusion. In Kenya and Tanzania, Kamau et al., (2023) and Were, Odongo and Israel (2021) found that compared to men, women were more likely to be financially illiterate and therefore less likely to be financially included in formal financial services which in turn increase their level of indebtedness. Adegbite and Machethe (2020) found a similar result in Nigeria, where the financial inclusion gender gap increased. They observed that the gap worsens when the agricultural sector is considered, especially in the case of smallholder farmers. In the area of digital literacy, there also exists gender disparity which the literature observes as a main hindrance to DFS usage (Kamau et al., 2023, Demirgüç-Kunt, et al. 2022; MCS, 2019).

It is evident from the above review that there is dearth of literature exists on the relative and complementary effect of DL and FL on DFI especially in the SSA region. Furthermore, none of the existing works has explored the factors accounting for the gender and location disparities in DFI, particularly in the SSA region.

3. Data and Methodology

3.1. Data Source

The study used the fifth wave of the Financial Insights (FII) survey on four SSA countries, namely Kenya, Nigeria, Tanzania, and Uganda collected between 2016 and 2017. The fifth wave unlike previous waves contains information on the three key variables of interest: DFI. DL and FL. The survey was initiated in 2013 in partnership with the Bill and Melinda Gates Foundation aimed at building meaningful knowledge about the financial landscape in four countries each from Africa (Kenya, Nigeria, Tanzania and Uganda) and Asia (Bangladesh, India, Indonesia, and Pakistan) (InterMedia, 2017). Specifically, the data covering these countries is pooled for the analysis. The survey gathered micro-level data from nationally representative samples of adults aged 15 years or older living in these four SSA countries. The major purpose was to track the adoption and use of traditional and digital financial services across diverse target demographics in the developing world, particularly among the poor, rural, and unbanked (InterMedia, 2017). Topics covered in the various waves include information on ownership and use of bank accounts, poverty indicators, and socio-economic and demographic indicators, use of non-formal financial services, digital and financial literacy indicators. The total number of individuals successfully surveyed in Kenya, Nigeria, Tanzania, and Uganda were 3000, 6352, 3,029, and 3000 respectively.

3.2. Measurement of key variables

We create an index of DFI by summing up indicators that capture ownership and use of electronic banking/mobile money services (See Appendix Table A7). The index is subsequently normalized to range from 0 to 1, where high values indicate more DFI, and low values indicate low DFI. We used the min-max normalization that rescales the index to range between 0 and 1 for easier interpretation of our results. By rescaling our index which is the dependent variable to range between 0 and 1, we can interpret the coefficient in percentages (by multiplying the coefficients by 100). However, it is also important to emphasize that rescaling the index to range between 0 and 1 does not change the significance of the results. Using the same approach, the financial literacy index was created by summing up seven questions covering key areas of risk diversification, inflation, simple and compound interests. These questions are standard across all countries and have been used in previous worldwide financial literacy surveys by the Organisation for Economic Cooperation and Development (OECD) and the World Bank (Klapper, & Lusardi, 2020; Klapper, Lusardi, & Van Oudheusden, 2015). The typical questions asked in the survey are displayed in Box 1 with correct answers in bold.

BOX 1

1.Imagine you have $200. Somebody gave you $100. How much total money will you have?
Option: **(A) $300**, (B) Any other answer, (C) Don't Know

2.Imagine you have $100, and you have to divide it among 5 people. How much money will each person receive if you divide it equally?
Option: (**A) $20**, (B) Any other answer, (C) Don't Know

3.Is it safer to put your money into one business or investment, or to put your money into multiple businesses or investments?
Option: (A) One business or investment, **(B) Multiple businesses or investments**, (C) Don't Know

4.Suppose over the next 10 years the prices of the things you buy double. If your income also doubles, will you be able to buy less than you can buy today, the same as you can buy today, or more than you can buy today?
Option: (A) Less, **(B) The same**, (C) More (D) Don't Know

5.Suppose you need to borrow $100. Which is the lower amount to pay back: $105 or $100 plus 3 percent? Option: (A) $105, **(B) $100 plus 3 percent**, (C) Don't Know

6.Suppose you put money in the bank for two years and the bank agrees to add 15 percent per year to your account. Will the bank add more money to your account the second year than it did the first year, or will it add the same amount of money both years?
Option: (A) The same, **(B) More** (C) Don't Know

7.Suppose you had $100 in a savings account and the bank adds 10 percent per year to the account. How much money would you have in the account after five years if you did not remove any money from the account?
Option: (A) Exactly $150, **(B) More than $150 local current** (C) Less than $150 (D) Don't Know

Following the standard in the literature (Klapper, & Lusardi, 2020; OECD, 2015), we build an index of financial literacy by counting the number of correct responses a respondent obtained on the seven financial literacy questions. After aggregating, the index ranges between 0 and 7, where 0 means the respondents answered all seven questions incorrectly and therefore classified as financially illiterate. In the same vein, seven means the respondent had all seven questions correct and reflects a higher level of financial literacy. Table A6 in the Appendix shows the proportion of respondents who answered each

question correctly. In our robustness check, we generated an alternative index for financial literacy using a factor analysis approach (see the robustness section for more details).

For the digital literacy part, in a series of six questions, respondents were asked whether they have the ability to perform the following tasks without any assistance from someone;
(a) *make and receive calls* (b) *navigate the menu on the phone,* (c) *Send and receive text messages* (d) *Use the internet* (e) *open a mobile money menu and* (f) *find a particular menu option (e.g., an option for a money transfer).*
For each of these questions, the respondent has four response options: i) No ability (ii) a little ability (iii) some ability (iv) complete ability. Consistent with the literature (Kass-Hanna, Lyons, & Liu, 2022), we recorded responses (ii) to (iv) as 1 reflecting ability and 0 otherwise. Following the approach in generating the financial literacy index, we constructed an index for digital literacy by aggregating the six dichotomous variables additively and thus, the score ranges between 0 reflecting no digital literacy and six denoting a higher level of digital literacy. Akin to the financial literacy variable, we generated an alternative index for digital literacy using the factor analysis method and discussed this in detail under the robustness section.

3.3. Control variables

To ensure our findings on the relationship between DL, FL, and DFI are accurate, we control for several individual-level socioeconomic characteristics in our model. These characteristics may influence both DFI and the adoption of DL and FL. For example, evidence suggests younger individuals tend to be more comfortable with technology, potentially leading to higher DL (Koomson et al., 2020a). Similarly, financial constraints associated with poverty can limit access to resources needed to develop DL and FL skills (Adegbite & Machethe, 2020). Location also plays a role, with urban areas often having better access to technology and educational resources that promote DL and FL compared to rural areas (Kamau et al., 2023). Marital status and educational attainment can also influence financial behaviour and the ability to acquire these skills (Tony & Kavitha, 2020). Finally, employment status can impact access to technology and resources needed to utilize digital financial services (Adegbite & Machethe, 2020). We further account for unobserved country-specific factors that might influence DFI, DL, and FL by incorporating country-fixed effects. By controlling for these potential confounding variables, we isolate the specific effect of DL and FL on DFI, leading to a more robust understanding of their interconnectedness.

3.4. Estimation Strategy

3.4.1. Estimation strategy for objective 1: Determine the effect of FL and DL on DFS usage in SSA

Based on the theoretical and empirical review, the study specifies the empirical model in equation (1) as follows:

$$\mathrm{DFI_{ij}} = \beta_0 + \beta_1 \mathrm{FL_{ij}} + \beta_2 \mathrm{DL_{ij}} + \eta \mathbf{Z}_{\mathrm{ij}} + \varepsilon_{\mathrm{ij}} \qquad (1)$$

where the DFI is an index that represents the level of digital financial inclusion (ownership and usage of DFS) by each respondent i in country j. Z_{ij} denotes a vector of controls discussed under Section 3.3 with η as its corresponding vector of coefficients. ε_{ij} which is the error term capturing the unobserved heterogeneities that are correlated with both the response variables and its covariates. It is assumed to be normally distributed with a mean of zero and a variance of unity. There is a potential source of endogeneity in our model that emanates from causalities between DL, FL and DFI and thus,

we estimate the model with 2SLS (Wooldridge, 2010). Although we hypothesised that DL and FL independently affect the adoption and use of digital financial services, the reverse may also hold. As individuals engage in specific financial practices, they are also likely to increase their overall financial competencies via the "learning by doing" process and this is likely to generate some feedback effect on DL and FL (Beck & Lusardi, 2018). At the same time, individuals who are more financially or digitally literate are more likely to use digital financial services, hence resulting in a reverse causality. The 2SLS regression requires implementing a two-stage estimation, with equations 2 and 3 representing the reduced equations and equation 4 representing the structural equation.

$$FL_{ij} = \delta_0 + \mathbf{I}_{ij}\boldsymbol{\alpha} + \mathbf{Z}_{ij}\eta + \varepsilon_{ij} \quad (2)$$

$$DL_{ij} = \delta_0 + \mathbf{W}_{ij}\boldsymbol{\beta} + \mathbf{Z}_{ij}\eta + \varepsilon_{ij} \quad (3)$$

$$DFI_{ij} = \beta_0 + \beta_1\widehat{FL}_{ij} + \beta_2\widehat{DL}_{ij} + \mathbf{Z}_{ij}\eta + \varepsilon_{ij} \quad (4)$$

where $\boldsymbol{I}_{ij}$ and $\boldsymbol{W}_{ij}$ are vectors of instruments for FL and DL respectively with $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are their respective corresponding vectors of parameters. $\widehat{FL}$ and $\widehat{DL}$ are the predicted values for FL and DL from the reduced equations. All other explanatory variables are the same as in equation (1). For our instrumental variable (IV) estimation to be feasible, the chosen instruments must satisfy two conditions namely the relevance condition and the validity condition. The relevance conditions require that the chosen instruments are statistically significant in explaining variations in the endogenous variables. Per the validity criterion, the IV must be correlated with the endogenous variable but uncorrelated with the response variable. With this condition, the study used two IVs: numeracy skills and language comprehension as instruments for DL and FL consistent with the DL and FL literature (Prete, 2022; Kass-Hanna, Lyons, & Liu, 2022; Morgan, & Trinh, 2019; Grohmann, Klühs, & Menkhoff, 2018).

Numeracy is dichotomous and thus, takes a value of 1 if a respondent answered both questions on addition and division skills correctly and 0 otherwise. For the addition question, participants were presented with a scenario where they were given 2,000 units of national currency and an additional 200 units. To answer correctly, the respondent had to choose the option "2,200 units". For the division question, participants were asked to divide 1,000 units equally among five people. To be considered correct, the respondent had to choose the option "200 units". To gauge the respondent's language comprehension levels, in the survey, respondents were presented with a consent form and thus, if a respondent was able to read and comprehend the informed consent form independently or with minimal assistance from the interviewer, they were assigned a value of 1 and 0 otherwise. The standard view in the literature is that while numeracy skills and language comprehension competencies directly influence DL and FL, these instruments only indirectly influence DFI through DL and FL (Prete, 2022; Kass-Hanna, Lyons, & Liu, 2022; Morgan & Trinh, 2019; Grohmann, Klühs, & Menkhoff, 2018).

3.4.2. Estimation strategy for objective 2: Ascertain the relative importance of financial and digital literacy to DFI in SSA.

The results generated from the regression approach represent the absolute effects of DL and FL on DFI, therefore nothing can be said about the relative importance of the two factors. To get an insight into this question, one has to extend the basic regression results or retransform the coefficients with the help of different methodological approaches. In this vein, this study used the dominance analysis to determine the relative importance of the various predictors of access to and use of digital financial services. This

method has the advantage that it can be applied to both linear and nonlinear regression models (Budescu, 1993).

Budescu (1993) presumed the fulfilment of three conditions in the analysis of importance. First, importance is defined in terms of a variable's 'reduction of error' in predicting. Second, the analysis allows for a direct comparison of relative importance and does not rely on inferred measures. Third, importance reflects a variable's direct effect, total effect, and partial effect. Specifically, the starting point of the dominance approach is an ordinal scaled comparison of the different explanatory variables. The impact of X_i on the outcome y dominates ("is more important than") another impact x_j if and only if

$$R^2(y.x_i.x_h) - R^2(y.x_h) \geq R^2(y.x_j x_h) - R^2(y.x_h) - R^2(y.x_h)$$

for all the possible subsets of $x_h(x_i,x_j,\in x_h).R^2$ is the goodness-of-fit measure of the respective subsets. For the following analysis, we use McFadden's pseudo-$R2$ (McFadden 1973) as a goodness-of-fit measure:

$$pseudo\ R^2(y.x) = 1\text{-}[\frac{ll(y.x)}{ll(0)}]$$

where $ll(y.x)$ is the log-likelihood of the respective models and $ll(0)$ is one of the constant-only models. Based on this dominance analysis, Budescu (1993) proposed a subsequent measure of the 'mean usefulness' of x_i

$$C_{X_i} = \sum_{k=0}^{p-1} C_{X_i}^{(k)}/p,$$

where p is the number of explanatory variables in the full model and $C_{X_i}^{(k)}$ the mean usefulness across all ($\frac{p-1}{k}$) models including k+1 variables (x_i and k other variables).

$$C_{X_i}^{(k)} = \sum [R^2(y.x_i,x_h) - R^2(y.x_h)]/(\frac{p-1}{k})$$

Finally, in order to get the relative importance weights of the impact of one variable compared to all the other variables, one has to calculate the importance weights W_{x_i}

$$W_{xi} = C_{x_i}/\sum_{j=0}^{p} C_{x_j}$$

According to Budescu (1993), this relative importance approach is fully consistent with dominance analysis only if the latter gives a clear ordering of the variable's importance. Therefore, one should interpret the weights of variables only where dominance analysis does give clear results.

3.4.3. Estimation strategy for objective 3: Assess whether digital and financial literacy has heterogenous effects across quantiles of DFI, gender and location.

To ascertain whether DL and FL have heterogeneous effects across the quantile DFI, the study employs instrumental variable quantile regression. Instrumental Variable Quantile Regression (IVQR) is a statistical technique that combines elements of IV analysis and quantile regression. It is particularly valuable when investigating the relationships between variables while accounting for endogeneity and simultaneously examining variations across different quantiles of the dependent variable. The gender and location dimensions of these objectives are achieved by running separate IV regressions across gender and location.

3.4.4. Estimation strategy for objective 4: Examine whether FL and DL can help reduce the inequalities in DFI across gender and location.

Our fourth objective seeks to examine, whether FL and DL can contribute to narrowing the gender and location inequalities in DFI. Therefore, to achieve this, that we implemented the Blinder-Oaxaca decompositions (Rahimi, & Hashemi Nazari, 2021; Jann, 2008; Oaxaca, & Ransom, 1994; Blinder, 1973). For a more detailed exposition of the implementation of this methodology in STATA is provided by Jann (2008).

3.5. Robustness checks

In the parlance of IV estimation, there is no such thing as perfect instruments. For instance, to determine the validity of instruments, analysts often depend on the Sargan/Hansen J statistics (depending on the type of standard errors used) to make such decisions. However, as noted by Wooldridge (2010; 2002), these test statistics only test the overidentification restrictions and not the exogeneity of all the instruments in the first-stage regression. To check for the predictive power of our instruments and the robustness of the baseline results, we implemented the Lewbel (2012) two-stage least squares with internal and external instruments. The Lewbel (2012) two-stage least squares method with internal and external instruments utilizes heteroscedasticity in the error term of the endogenous variable to construct valid internal instruments. The Lewbel (2012) approach has been widely used to check the robustness of estimates from IV estimations (Churchill & Marisetty, 2019; Bukari et al., 2023). Additionally, the Fairlier's approach to decomposition analysis was also employed to assess the robustness of our decomposition results (Fairlie, 2005).

3.6 Descriptive analysis

Table 1 provides a descriptive statistic of the variables used in the analysis. Beginning with our response variable (DFI), Table 1 indicates that while the average digital financial inclusion rate is approximately 11 percent, nearly 41 percent of the respondents are digitally financially included. Regarding our two independent variables of interest (DL and FL), on average 42 percent are digitally literate while 52 percent are financially literate. Also, the majority of the respondents are females (58.0%) and live in rural regions (75 %). In terms of the age distribution, we find that 26.2 percent of the respondents fall within the age bracket of 15-24 years old, 29.4 percent of the respondents belong to the age bracket of 25-34 years old, and 11.3 percent also belong to the age bracket of 45-54 years old. In addition, majority of those who participated had completed at least some degree of their formal education (81 percent), considered themselves to be Christians (67.8 percent), and were in monogamous relationships.

Table 1: Descriptive Statistics of Respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
DFI (continuous)#	15232	0.107	0.161	0	1
DFI (Dummy)	15232	0.410	0.492	0	1
Digital literacy (DL) (continuous)#	15232	0.415	0.327	0	1
Financial literacy (FL) #	15232	0.517	0.191	0	1
Male	15232	0.424	0.494	0	1
Urban	15232	0.352	0.478	0	1
15-24	15232	0.262	0.440	0	1
25-34	15232	0.294	0.456	0	1
35-44	15232	0.185	0.388	0	1
45-54	15232	0.113	0.317	0	1

55 and beyond	15232	0.145	0.352	0	1
Age #	15232	36.01	15.88	15	117
Employee	15158	0.339	0.473	0	1
Self employed	15158	0.336	0.472	0	1
Unpaid work	15158	0.090	0.286	0	1
Other work	15158	0.193	0.395	0	1
Unemployed	15158	0.042	0.201	0	1
No education	15204	0.145	0.352	0	1
Prim education	15204	0.377	0.485	0	1
Secondary education	15204	0.335	0.472	0	1
University education	15204	0.099	0.299	0	1
Other education	15204	0.043	0.203	0	1
Christianity	15226	0.678	0.467	0	1
Islam	15226	0.309	0.462	0	1
Other religion	15226	0.013	0.114	0	1
Below poverty line	15232	0.526	0.499	0	1
Never married	15232	0.282	0.450	0	1
Polygamous married	15232	0.126	0.332	0	1
Monogamous married	15232	0.422	0.494	0	1
Divorced/Separated	15232	0.048	0.214	0	1
widowed	15232	0.070	0.256	0	1
Cohabitation	15232	0.044	0.205	0	1
Other married	15232	0.006	0.079	0	1
IVs					
Numeracy	15232	0.970	0.171		
Language comprehension	15232	0.580	0.494		
Kenya	15232	0.205	0.404	0	1
Tanzania	15232	0.197	0.398	0	1
Nigeria	15232	0.397	0.489	0	1
Uganda	15232	0.201	0.401	0	1

Note: variables with a # attached are indices.

Source: Financial inclusion insight survey-2016/2017

4. Results

4.1. Baseline results

Effect of digital and financial literacy on digital financial inclusion (DFI)

Table 2 presents the findings from the 2SLS regression, which serve as our baseline results regarding the effects of DL and FL on DFI. As detailed in Section 3.3.1, we posit that DL and FL may be endogenous variables, susceptible to issues such as reverse causality, omitted variable bias, and measurement error. Consequently, the results derived from the 2SLS method are particularly pertinent as they effectively address the endogeneity concern. To explicitly confirm our suspicion of endogeneity, we performed two separate endogeneity tests namely the Durbin and Wu-Hausman test both with the null hypothesis that DL and FL are exogenous (that is uncorrelated with the error term) and the results are reported in Table 2. Overall, at a one percent level of significance, both the Durbin and Wu-Hausman tests reject the null hypothesis that DL and FL are exogenous. Thus, we correct for the endogeneity in an instrumental variable two-stage least squares (IV 2SLS) using numeracy and language comprehension as IVs and the results are presented in Table 2.

Panels A and B of Table 2 present the second and first-stage results of the IV-2SLS regression, respectively. In the first stage results presented in Panel B, we find a strong link between the endogenous

variables and the IV. In Panel B, we find strong evidence that the IVs significantly influence the endogenous variables. Specifically focusing on column (1) of Panel B, we can see that having language comprehension and numeracy skills increases DL and FL by 15.1 percentage points and 34.0 percentage points respectively compared to not having such skills. Importantly, the F-statistics for the IVs are significant and larger than the conventional threshold of 10 set by Stock and Yogo, (2005), hence, implying that these IVs are relevant predictors of digital and financial literacy. In the literature (see e.g., Staiger and Stock, 1997; Lee et al., 2022), Anderson and Rubin's (1949) test has been projected as key in determining whether an IV is weak or otherwise. Therefore, we carried out this test and as shown in Table 2, at a one percent level of significance, we reject the null hypothesis that our chosen IVs are weak.

Now we turn attention to IV 2SLS results presented in Panel A of Table 2 where Columns 1 presents results for the full sample, Columns (2)— (3) and (4)— (5) represent results for the gender and locational dimensions respectively. Overall, in Panel A of the table, we highlight three key findings. First, we find that both DL and FL individually have positive influence on DFI. Specifically, DL and FL increase DFI by 22.0 percentage points and 4.2 percentage points respectively. These effects are statistically significant at a one percent alpha level, implying that both digital and financial literacy improves DFI. These results align with the findings of studies that have advocated for improvements in DL and FL in SSA (Kamau et al., 2023; Adegbite & Machethe, 2020; Koomson et al., 2020a; Matita & Chauma, 2020; Demirgüç-Kunt et al., 2018). These results also support the technology acceptance theory in both DL and FL enhancing the adoption of DFI (Marikyan & Papagiannidis, 2022).

The results of analysing the gender dimensions are shown in Columns (2)— (3). We find that DL and FL separately enhance DFI across both genders. However, their effects vary significantly. Precisely, while DL favours females more than males with a differential magnitude of 2.1 percentage points, the reverse holds firmly for FL with a differential magnitude of 5.1 percentage points in favour of males.

The results of analysing the rural-urban dimension are shown in Columns (4)— (5). We find significant heterogeneities among rural and urban folks. Specifically, we find that the effect of DL on DFI is much more intense among urban dwellers. Precisely, the effect of DL on DFI is 21.4 percentage points among males and 23.5 percentage points among females resulting in a differential effect of 3.6 percentage points in favour of females. In contrast, the effect of FL is much more pronounced among the rural dwellers. This finding aligns with existing literature that has highlighted that both digital literacy skills and financial services in developing economies are heavily skewed toward males and those in urban areas (Yang and Huang, 2023; Koomson et al., 2020a; Koomson et al., 2020b; Beck, Demirgüç-Kunt, & Maksimovic, 2008).

Table 2: IV 2SLS Results of the effects of digital and financial literacy on digital financial inclusion

	(1)	(2)	(3)	(4)	(5)
		Gender		Location	
	Full	Male	Female	Urban	Rural
Panel A: Instrumental Variable (IV) Two-stage Least Squares Estimates					
Digital literacy	0.220***	0.214***	0.235***	0.278***	0.242***
	(0.017)	(0.031)	(0.020)	(0.039)	(0.018)
Financial Literacy	0.042**	0.079**	0.028	-0.018	0.035*
	(0.018)	(0.036)	(0.021)	(0.044)	(0.019)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes

Panel B: Instrumental Variable First-Stage Estimates					
Language comprehension	0.151***	0.134***	0.164***	0.133***	0.161***
	(0.004)	(0.007)	(0.006)	(0.007)	(0.005)
Numeracy	0.340***	0.357***	0.339***	0.368***	0.339***
	(0.009)	(0.017)	(0.010)	(0.021)	(0.010)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
F-statistic	1200.71***	642.640***	753.030***	567.720***	789.120***
Under ident. test	607.163***	176.189***	429.672***	135.601***	476.166***
Weak ID test	315.930***	90.383***	225.605***	69.388***	249.869***
Anderson-Rubin test	270.430***	111.21***	209.700***	69.270***	285.570***
Durbin chi-square	8.01**	5.53**	6.52**	8.96***	8.99***
Wu-Hausman F-statistic	8.32***	2.76***	2.89***	4.51***	4.49***
Observations	15,141	6,419	8,722	5,329	9,812
R-squared	0.583	0.599	0.572	0.613	0.558

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
The instruments for digital and financial literacy are language comprehension and numeracy. We control for the following variables the individual's age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. Details on the coefficients for these control variables are available in Appendix Tables A1. All models control for country-specific fixed effects.

4.2. *Effect of digital literacy and financial literacy on decomposed measures of DFI*

Table 3 presents the results of the effect of DL and FL on decomposed measures of DFI. Here, we focused on three key dimensions of DFI namely ownership, savings usage and financial transaction usage. The first dimension is ownership of a digital account which we set equal to 1 if the individual owns a mobile money account or financial account linked to a mobile phone or belongs to a savings group linked to a mobile money account and 0 otherwise. In Panel A of Table 3, we present the instrumental probit marginal effects of DL and FL on ownership of a digital account. Our second dimension of DFI is digital savings which we set equal to 1 if the respondent saves money using a digital account and 0 otherwise and Panel B presents results for this dimension. Our final dimension of DFI is financial transaction usage which takes on a value of 1 if the respondents use the digital accounts for any financial transaction such as payment of school fees, medical bills, investments, shopping, etc (except for savings) and 0 otherwise and in Panel C, we show the result of the effect of DL and FL on this dimension.

Overall, in Table 3 we highlight three important findings. Our first finding relates to the ownership dimension in Panel A where we find that DL stimulates people's likelihood of owing a digital account and the effect is more pronounced among males and those in rural areas. Our second findings emanate from Panel B where we find that both DL and FL raise individuals' probabilities of adopting digital savings, but significant heterogeneities exist. While the effect of DL on the adoption of digital savings is more intense among males and rural dwellers, the effect of FL stimulating the adoption of digital savings is intense among females and those in rural areas. Finally, in Panel C, we find that the effect of DL in improving the usage of digital financial services is pronounced among males and those in rural settings where the effect of FL is also much more intense.

Table 3: IV probit marginal effects of digital and financial literacy on decomposed measures of DFI

	(1)	(2)	(3)	(4)	(5)
		Gender		Location	
	Full	Male	Female	Urban	Rural

Panel A: Effects of digital and financial literacy on ownership of a digital account					
Digital literacy	0.030***	0.036***	0.027***	0.031***	0.030***
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Financial literacy	0.002	-0.003	0.005	0.005	0.002
	(0.003)	(0.006)	(0.003)	(0.007)	(0.003)
Individual characteristics?	Yes	Yes	Yes	Ye	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
Wald χ^2	4312.410***	2358.700***	2093.840***	1914.110***	2425.510***
Observations	15,215	6,443	8,772	5,352	9,863
Panel B: Effects of digital and financial literacy on digital savings					
Digital literacy	0.023***	0.025***	0.021***	0.023***	0.024***
	(0.002)	(0.004)	(0.003)	(0.004)	(0.003)
Financial literacy	0.012***	0.014*	0.011**	0.003	0.013***
	(0.004)	(0.008)	(0.005)	(0.008)	(0.005)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
Wald χ^2	2858.910***	1495.960***	1449.450***	1170.370***	1614.690***
Observations	15,215	6,443	8,772	5,352	9,863
Panel C: Effects of digital and include literacy on digital financial transaction usage					
Digital literacy	0.037***	0.041***	0.034***	0.036***	0.037***
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Financial literacy	0.005	0.005	0.006	0.001	0.007*
	(0.003)	(0.006)	(0.004)	(0.007)	(0.004)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
Wald χ^2	4548.87***	2411.630***	2160.830***	1886.000***	2578.020***
Observations	15,215	6,443	8,772	9,863	9,863

Notes: Digital account is dichotomous and set equal to 1 if the individual saves money through a mobile phone linked to a financial account including mobile money and 0 otherwise. Digital literacy and financial literacy had been rescaled to range between 0 and 100. The individual's characteristics include age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. The instruments are numeracy and literacy skills and each is set to equal 1 if the individual has basic numeracy and language comprehension skills and 0 otherwise.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3. *Do financial and digital literacy equally matter in improving DFI in SSA?*

In Table 4, we present the results assessing the relative importance of DL and FL on DFI. In Table 4, we report both the dominance statistic (Dom. Stat.) and a variable ranking (Rank) where we highlight three important findings. First, generally, we find that DL is the most important predictor of DFI, accounting for over 80.0 percent of the predicted variance and this holds uniformly across gender and location. Poverty (i.e., living below the World Bank poverty line) is the second important factor contributing to the low DFI adoption and it is particularly true among females and those in rural areas. While mobile money services offer cost-effective alternatives to traditional banking, their adoption often necessitates financial commitments that individuals living in poverty may find challenging to meet. The initial costs associated with setting up and maintaining mobile money accounts, though

relatively low, can still pose barriers to entry for those with limited financial resources. Additionally, ongoing transaction fees for various services can deter individuals from utilizing mobile money platforms, particularly when financial resources are scarce. The third most important contributor to the low DFI adoption is religion. This finding aligns with the existing literature linking religion to financial inclusion (Andani, 2021; Abdu et al., 2018). Existing empirical evidence indicates that people are more inclined to adopt services if they perceive them to be in line with their religious values. This may explain why religion is a main predictor of DFI adoption. Also, within the SSA region, religious bodies serve as an informal channel through which individuals gain knowledge about new financial products in terms of their benefits and how they function.

Table 4: Relative effects of financial and digital literacy on DFI

	(1) Full	(2)	(3) Male	(4)	(5) Female	(6)	(7) Urban	(8)	(9) Rural	(10)
	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank
Digital literacy	0.8093	1	0.8366	1	0.7814	1	0.8636	1	0.7934	1
Financial literacy	0.0073	8	0.0052	8	0.0101	9	0.0049	8	0.0092	7
Male	0.0042	9					0.0038	9	0.0064	8
Urban	0.0159	5	0.0081	7	0.0242	4				
Age	0.0142	6	0.0119	5	0.0161	6	0.0224	4	0.0153	5
Employed	0.0115	7	0.0086	6	0.0137	7	0.0109	6	0.0126	6
Married	0.0031	10	0.0028	9	0.0106	8	0.0098	7	0.0009	9
Poverty	0.0714	2	0.0525	3	0.0881	2	0.0249	3	0.0958	2
Educated	0.0190	4	0.0131	4	0.0240	5	0.0168	5	0.0163	4
Religion	0.0440	3	0.0613	2	0.0318	3	0.0428	2	0.0502	3
Overall Fit Statistic	0.4494		0.4411		0.4629		0.4515		0.4482	
Observations	15141		6419		8722		5329		9812	

Notes: The dependent variable is digital financial inclusion normalised to range between 0 and I for easier interpretation. The key independent variables are digital literacy and financial literacy, also rescaled to range between 0 and 1 for easier interpretation. The individual's characteristics include age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion.

4.4. *Complementary effects of DL and FL on DFI*

Table 5 presents the findings on the complementary effects of DL and FL on DFI. The first column shows the full model results, while columns 2 and 3 disaggregate the analysis by gender (male and female), and columns 4 and 5 disaggregate by location (urban and rural). Our primary focus is on the interaction term (Digital Literacy * Financial Literacy). The interaction term is positive and significant in the full model (column 1). This suggests that increasing both DL and FL concurrently has a stronger positive effect on DFI compared to increasing only one of these literacies. Interestingly, the interaction effect seems to be driven primarily by females (column 3) and rural dwellers (column 5). For females, having both high DL and FL leads to a greater increase in DFI compared to males. When we analyze by location, the positive interaction effect is more pronounced in rural areas (column 5). This suggests that combined improvements in DL and FL have a greater impact on DFI in rural communities compared to urban areas.

Table 5: IV 2SLS Results of the complementary effects of financial and digital literacy on digital financial inclusion (DFI)

	(1)	(2)	(3)	(4)	(5)
		Gender		Location	

	Full	Male	Female	Urban	Rural
Panel A: Instrumental Variable (IV) Two-stage Least Squares Estimates					
Digital literacy (DL)	0.063	0.061	0.114	0.205	0.066
	(0.087)	(0.133)	(0.117)	(0.216)	(0.093)
Financial Literacy (FL)	-0.005	0.018	-0.006	-0.048	-0.016
	(0.031)	(0.065)	(0.036)	(0.093)	(0.032)
DL*FL	0.275*	0.263	0.259***	0.127	0.309*
	(0.148)	(0.224)	(0.079)	(0.358)	(0.162)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
Panel B: Instrumental Variable First-Stage Estimates					
Language comprehension	0.068***	0.058	0.077***	0.049	0.344***
	(0.024)	(0.050)	(0.028)	(0.043)	(0.011)
Numeracy	0.124***	0.115***	0.119***	0.162***	0.107***
	(0.011)	(0.027)	(0.012)	(0.022)	(0.013)
Language comprehension*Numenracy	0.106***	0.117**	0.099***	0.098**	0.102***
	(0.021)	(0.047)	(0.023)	(0.039)	(0.025)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effect?	Yes	Yes	Yes	Yes	Yes
Under ident. test	69.796***	12.424***	59.380***	35.868***	35.74***
Weak ID test	23.348	4.139	19.883	11.995	11.942
Observations	15,141	6,419	8,722	5,329	9,812
R-squared	0.583	0.599	0.572	0.613	0.558

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
The instruments for digital and financial literacy are language comprehension and numeracy. We control for the following variables the individual's age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. Details on the coefficients for these control variables are available in Appendix Tables A1. All models control for country-specific fixed effects.

4.5. *Do digital and financial literacy have heterogeneous effects across quantiles of DFI, gender and location?*

Panel A under Table 5 represents the results of assessing whether DL and FL have heterogeneous effects across quantiles of DFI, gender and location. We find that the estimated coefficient of DL is higher at higher quantiles of DFI. This suggests that improvements in DL benefit those in the middle and upper quantiles more than those in the lower quantile of DFI. To confirm this finding, we performed a constant coefficient hypothesis test (see Table A13 in the Appendix). The test statistic shows that at 95% confidence level, we can reject the constant effect hypothesis, and thus conclude that DL indeed has more effect at the higher levels of DFI than the lower levels of DFI. Several factors may account for this finding including limited access to other facilitating conditions. For instance, individuals with lower DFI face other limitations in terms of digital resource accessibility, including internet and device access, which could hinder their engagement in DFI even with an increase in DL (FII survey, 2017). Additionally, individuals with higher DFI may grapple with more complex financial situations, which demand a higher level of DL for effective management.

When it comes to FL, we find that the estimated effect on DFI is significant at only lower quantiles of DFI (i.e. up to the 50th quantile). This suggests that FL is beneficial to only those in the lower and middle quantiles of DFI. We further confirm this finding by testing the constant effect (see Table A11 in the Appendix). The test statistic shows that at 95% confidence level, we can reject the constant effect hypotheses. This finding may reflect the nature of financial literacy programmes offered in the region.

Financial literacy programs often focus on basic financial concepts that might already be well-understood by individuals with high DFI which may explain why increments in FL have no effect on DFI.

Crucially, we also disaggregate the analysis across gender (Panel B) and location (Panel C). By gender, DL generally benefits females more than males. In contrast, the effect of FL is more intense among males in the lower and middle quantile and females in the middle quantile compared to another group of quantiles. In terms of location, the effect of DL on DFI is intense among urban dwellers in the lower and median quantiles and for rural dwellers in the upper quantiles. Meanwhile, the effect of FL on DFI is more pronounced among rural dwellers in the middle quantile relative to other groups of quantiles.

Table 5: Heterogenous effects of digital and financial literacy on DFI by gender and location (IV-Quantile estimates)

	(1)	(2)	(3)	(4)				
Panel A: Instrumental Quantile results of the effects of digital and financial literacy on DFI (Full sample)								
	q25	q50	q75	q90				
Digital literacy	0.053***	0.152***	0.227***	0.234***				
	(0.009)	(0.018)	(0.034)	(0.034)				
Financial literacy	0.020**	0.080***	0.040	0.005				
	(0.008)	(0.017)	(0.027)	(0.012)				
Constant	-0.026***	-0.021**	0.065**	0.175***				
	(0.006)	(0.010)	(0.032)	(0.025)				
Observations	15,141	15,141	15,141	15,141				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Male				Female			
VARIABLES	q25	q50	q75	q90	q25	q50	q75	q90
Panel B: Instrumental Quantile results of the effects of digital and financial literacy on DFI (Gender sample)								
Digital literacy	0.065***	0.114***	0.189***	0.259***	0.057***	0.190***	0.291***	0.265***
	(0.018)	(0.025)	(0.057)	(0.065)	(0.012)	(0.021)	(0.025)	(0.045)
Financial literacy	0.051**	0.168***	0.049	0.002	0.013	0.041**	0.026	0.009
	(0.022)	(0.033)	(0.071)	(0.030)	(0.009)	(0.017)	(0.027)	(0.013)
Constant	-0.029**	0.001	0.112**	0.179***	-0.029***	-0.036***	0.012	0.145***
	(0.011)	(0.021)	(0.057)	(0.050)	(0.007)	(0.013)	(0.030)	(0.030)
Observations	6,419	6,419	6,419	6,419	8,722	8,722	8,722	8,722
Panel C: Instrumental Quantile results of the effects of digital and financial literacy on DFI (location sample)								
	Urban				Rural			
	q25	q50	q75	q90	q25	q50	q75	q90
Digital literacy	0.134***	0.238*	0.147***	0.192***	0.052***	0.186***	0.310***	0.346***
	(0.034)	(0.133)	(0.055)	(0.055)	(0.009)	(0.020)	(0.020)	(0.049)
Financial literacy	0.030	0.008	0.034	0.014	0.012	0.040***	0.036	0.004
	(0.029)	(0.147)	(0.031)	(0.025)	(0.008)	(0.013)	(0.022)	(0.012)
Constant	-0.045**	-0.019	0.187***	0.182***	-0.027**	-0.035***	0.010	0.104***

	(0.017)	(0.063)	(0.046)	(0.064)	(0.006)	(0.011)	(0.019)	(0.036)
Observations	5,329	5,329	5,329	5,329	9,812	9,812	9,812	9,812

Notes: The dependent variable is digital financial inclusion normalised to range between 0 and I for easier interpretation. The key independent variables are digital literacy and financial literacy, also rescaled to range between 0 and 1 for easier interpretation. The individual's characteristics include age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. The instruments for digital and financial literacy are numeracy and language comprehension skills respectively and each is set to equal 1 if the individual has basic numeracy and language comprehension skills and 0 otherwise. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.6. *Can digital and financial literacy help reduce the inequalities in DFI across gender and location?*

In Table 6, we represent the results of the effect of DL and FL in narrowing the inequalities in DFI across gender and location. Panel A shows evidence of the DFI gender and location gaps, while Panel B shows the causal factor of these gaps where we pinpoint three key findings. We first focus on Panel A where we find that 47.1 percent of the males are digitally financially included while 37.0 percent of the women are digitally financially included, producing a DFI gender gap of 10.2 percentage points in favour of males. By location, 57.2 percent and 32.6 percent of urban and rural dwellers participate in the digital financial markets, hence, resulting in a DFI location gap of 24.6 percentage points in favour of urban dwellers. Secondly, we find that significant parts of the DFI gender and location gaps are largely due to differences in endowments between the groups. Thus, adjusting females' endowments in DL and FL skills to be at par with their male counterparts will reduce the DFI gender by 77.5 percent. In terms of the causal factors, DL account for over half (71.1%) of the DFI gender gap while FL account for 6.0 percent. Regarding the DFI location gap, we find that adjusting rural dwellers' endowments in DL and FL skills to be at par with their urban counterparts will reduce the DFI location gaps by 62.6 percent. In terms of the causal factors, we find that while DL accounts for 68.3% of the location gap, FL contributes 3.0 percent.

Table 6: Effects of DL and FL in narrowing DFI gender and location gaps

VARIABLE	(1) Gender	(2) Location
Panel A: Evidence of DFI gender and location gaps		
Men	0.471***	
	(0.006)	
Women	0.370***	
	(0.005)	
Urban		0.572***
		(0.007)
Rural		0.326***
		(0.005)
Difference (gap)	0.102***	0.246***
	(0.008)	(0.008)
Total gap explained:	0.083***	0.164***
	(0.005)	(0.006)
	[81.4%]	[63.1%]
Endowments	0.079***	0.154***
	(0.006)	(0.006)
Coefficients	0.015**	0.066***
	(0.007)	(0.009)
Interaction	0.008*	0.026***
	(0.004)	(0.007)
Panel B: Causal factors for DFI gender and location gaps (Decompositions)		
Digital literacy	0.059***	0.112***
	(0.004)	(0.004)

	[71.1%]	[68.3%]
Financial literacy	0.005***	0.005***
	(0.001)	(0.001)
	[6.0%]	[3.0%]
Observations	15,141	15,141

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Notes: A positive (+) sign indicates an advantage for males and urban dwellers while a negative (-) sign shows an advantage for females and rural dwellers. Robust standard errors are in parentheses while the contributions in percentage terms are shown in brackets. We applied individual weights. We control for the following variables the individual's age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. Details on the contributions of the controls to the DFI gender and location gap are available in Appendix Tables A2. All models control for country-specific fixed effects.

4.7. Further analysis and Robustness checks

4.7.1. Alternative estimation strategy and measurements for the effect of FL, DL on DFI

Here, we employ an alternative measurement of digital literacy, financial literacy, and DFI. We use factor analysis precisely the principal-component factors approach to construct an index for (1) DL using six indicators, (2) FL using seven indicators and (3) digital financial inclusion (DFI) using seventeen indicators. Tables A7, A8, and A9 in the Appendix provide detailed information on the list of indicators for DL, FL, and DFI indexes respectively. For each of the three indexes and based on the principal-component factors approach, we retained the factors with eigenvalues greater than one and importantly, the retained factors explained over half of the variations in each index (see Tables A10, A11 and A12 in the appendix). Regarding the index for DL, the retained factors explained 73.4 percent of the variations in DL (see Table A10). For the FL index, the retained factors explained 53.7 percent of the variations in FL (see Table A11). Finally, the retained factors in the index for DFI contributed to over 50 percent of the variations in DFI (see Table A12).

Using these new measures of DL, FL, and DFI, we implemented the Lewbel (2012) two-stage least squares as an alternative to the standard IV 2SLS presented in Table A3. The key benefit of the Lewbel (2012) IV-2SLS over 2SLS is that, unlike the IV 2SLS, the Lewbel approach does not require any external instruments. It relies on heterogeneity in the error term from the first stage regression to generate internally valid instruments (Bukari et al., 2023; Grohmann et al., 2018; Lewbel, 2012). As displayed in Table 7, the results from additional examination are entirely consistent with our baseline estimates presented in Table 2. We find that it significantly stimulates DFI.

Table 7: effects of digital and financial literacy on DFI (Lewbel 2012 2SLS estimates)

	(1)	(2)	(3)	(4)	(5)
		Gender		Location	
VARIABLES	Full	Male	Female	Urban	Rural
Digital literacy	0.161***	0.127***	0.179***	0.174***	0.187***
	(0.014)	(0.021)	(0.019)	(0.027)	(0.018)
Financial literacy	0.153***	0.219***	0.117***	0.165***	0.146***
	(0.014)	(0.023)	(0.019)	(0.029)	(0.017)
Individual characteristics?	Yes	Yes	Yes	Yes	Yes
Country fixed effects?	Yes	Yes	Yes	Yes	Yes
Constant	0.231***	0.276***	0.205***	0.244***	0.196***
	(0.022)	(0.032)	(0.031)	(0.045)	(0.025)
Observations	11,894	5,236	6,658	4,308	7,586
F-statistic	837.25***	476.39***	452.31***	434.73***	485.48***
R-squared	0.500	0.542	0.475	0.567	0.462

Notes: Dependent variable is digital financial inclusion generated using Principal-component factor approach and normalized

to range between 0 and 1. The two independent variables digital Literacy and financial literacy variables were also generated using the same approach. In each model, we controlled for the individual's age, gender, rural-urban location, employment, educational attainment, poverty, marital status and religion. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

In Table 8, we represent the results of the effect of DL and FL in narrowing the inequalities in DFI across gender and location using alternative estimation approach precisely the Fairlie's approach (Fairlie, 2005). Fairlie (2005) is an extension of the Blinder-Oaxaca decomposition technique nonlinear model (e.g., logit and probit models). When the distribution is centred around the mean, Fairlier's estimates approximate Blinder-Oaxaca estimates. However, when the distribution is centred around the tails, Fairlier's estimates are robust to Blinder-Oaxaca's estimates. For example, Fairlier's estimates as shown in Table 8 do not deviate from the Blinder-Oaxaca estimates presented in Table 6. Precisely, Table 8 indicates that Fairlier's model established the gender and location gaps to be 10.2 percentage and 24.6 percentage points and this is entirely consisted with the Blinder-Oaxaca estimates presented in Table 6, Again, similar to the Blinder-Oaxaca (OB) model presented in Table 6, Fairlier's model explained 83.3% and 72.4 of the total gender and location gaps respectively (note that is 81.4% and 63.1% for the OB model in Table 6). In terms of the causal factors, Similar to the OB estimates presented in Table 6, Failier's estimates in Table 7 show that DL contributes to over half of both gender (57.6%) and location (64.0%) gaps. The contribution of FL to the gender and location gaps is around 4.0% and 2.2% respectively.

Table 8: Effects of DL and FL in narrowing DFI gender and location gaps (Fairlier's Approach)

	(1)	(2)
VARIABLE	Gender	Location
Panel A: Evidence of DFI gender and location gaps		
Men	0.471	
Women	0.370	
Urban		0.572
Rural		0.326
Difference (gap)	0.102	0.246
Total gap explained:	0.085	0.178
	[83.3%]	[72.4%]
Panel B: Causal factors for DFI gender and location gaps (Decompositions)		
Digital literacy	0.049***	0.114***
	(0.001)	(0.002)
	[57.6%]	[64.0%]
Financial literacy	0.003***	0.004***
	(0.001)	(0.001)
	[3.5%]	[2.2%]
Observations	15,141	15,141

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Notes: A positive (+) sign indicates an advantage for males and urban dwellers while a negative (-) sign shows an advantage for females and rural dwellers. Robust standard errors are in parentheses while the contributions in percentage terms are shown in brackets. We control for the following variables the individual's age, gender, rural-urban location, marital status, poverty, educational attainment, employment status and religion. Details on the contributions of the controls to the DFI gender and location gap are available in Appendix Table A2. All models control for country-specific fixed effects.

5. Conclusion and recommendations

The SSA region has made significant strides in the supply of digital financial services. Yet, the rate of adoption remains low with acute gender and location inequalities compared to more developed regions. We contribute to the nascent literature by providing a comprehensive analysis of the relevance of digital literacy and financial literacy to DFI in the SSA region. Specifically, we examine the effect of DL and

FL on DFI. Our results show that both FL and DL separately and collectively have a positive impact on DFI. Further, we assess the relative importance of DL and FL on DFI and finally analyse the potential heterogeneities in the effect of FL and DL across gender, rural, and urban areas on DFI. we find that DL has a relatively higher importance than FL. However, it is important to note that these effects are heterogeneous, across gender, location, and DFS usage especially when looking at quantiles. That is, females in rural areas benefit more from improvement in DL and FL than males and urban dwellers. The findings from the Blinder and Oaxaca decomposition also show that equalising the DL for females and those in rural areas would reduce the DFI gender and location gaps the most.

Based on these insightful findings, we recommend that policymakers in the region continue to prioritize the implementation of policies aimed at promoting both DL and FL. It is evident that both these literacy dimensions have a positive impact on DFI. However, policymakers must tailor their efforts with a keen awareness of the location, gender, and the existing level of DFI usage among individuals. In urban areas, we propose a specific focus on bolstering DL programs, recognizing the urban population's relatively higher exposure to digital financial services. In this context, giving precedence to digital literacy over FL programs is justified, considering its stronger influence on DFI outcomes. Furthermore, to address the prevalent gender and location disparities in DFI within the region, policymakers must design and implement targeted initiatives. These programs should specifically aim at enhancing DL among rural residents and women. Achieving this goal will require a multifaceted approach, which may encompass programmes that promote the numeracy and literacy skills of individuals. A limitation of this study is that our analysis is based on four out of the 48 countries in the SSA region and thus, caution should be taken in any attempt to generalise the findings to the entire region.

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Appendix

Table A1: Effects of digital and financial literacy on DFI (IV-2SLS)

	(1)	(2)	(3)	(4)	(5)
		Gender		Location	
	DFSfull	Male	Female	Urban	Rural
VARIABLES	DFI	DFI	DFI	DFI	DFI
Digital literacy	0.220***	0.214***	0.235***	0.278***	0.242***
	(0.017)	(0.031)	(0.020)	(0.039)	(0.018)
Financial Literacy	0.033*	0.079**	0.028	0.018	0.035*
	(0.018)	(0.036)	(0.021)	(0.044)	(0.019)
Male	0.001			0.001	-0.003
	(0.002)			(0.004)	(0.003)
urban	0.007***	0.005	0.008***		
	(0.002)	(0.003)	(0.003)		
Age	0.003***	0.000*	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employ	0.014***	0.026***	0.015***	0.023***	0.015***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
married	0.005**	0.022***	0.001	0.005	0.011***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Poverty	-0.017***	-0.021***	-0.013***	-0.011*	-0.018***
	(0.003)	(0.005)	(0.004)	(0.006)	(0.003)

Educated	0.018***	0.018***	0.015***	0.016**	0.011***
	(0.003)	(0.005)	(0.004)	(0.006)	(0.003)
Being Muslim	-0.001	0.001	-0.003	-0.040**	-0.012
	(0.008)	(0.011)	(0.011)	(0.018)	(0.008)
Being Christian	0.015*	0.010	0.020*	0.047***	0.008
	(0.008)	(0.011)	(0.011)	(0.018)	(0.008)
Constant	-0.063***	-0.031	-0.044***	-0.058**	-0.042***
	(0.011)	(0.021)	(0.014)	(0.028)	(0.012)
Panel B:IV 2SLS first-stage Results					
Numeracy	0.340***	0.357***	0.339***	0.368***	0.339***
	(0.009)	(0.017)	(0.010)	(0.021)	(0.010)
Language comprehension	0.151***	0.134***	0.164***	0.133***	0.161***
	(0.004)	(0.007)	(0.006)	(0.007)	(0.005)
F-statistic	1200.71***	642.640***	753.030***	567.720***	789.120***
Under ident. test	607.163***	176.189***	429.672***	135.601***	476.166***
Weak ID test	315.930***	90.383***	225.605***	69.388***	249.869***
Anderson-Rubin test	270.430***	111.21***	209.700***	69.270***	285.570***
Observations	15,141	6,419	8,722	5,329	9,812
R-squared	0.583	0.599	0.572	0.613	0.558

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2: Effects of DL and FL in narrowing DFI gender and location gaps

VARIABLE	(1) Gender	(2) Location
Panel A: Evidence of DFI gender and location gaps		
Men	0.471***	
	(0.006)	
Women	0.370***	
	(0.005)	
Urban		0.572***
		(0.007)
Rural		0.326***
		(0.005)
Difference (gap)	0.102***	0.246***
	(0.008)	(0.008)
Total gap explained:	0.083***	0.164***
	(0.005)	(0.006)
	[81.4%]	[63.1%]
Endowments	0.079***	0.154***
	(0.006)	(0.006)
Coefficients	0.015**	0.066***
	(0.007)	(0.009)
Interaction	0.008*	0.026***
	(0.004)	(0.007)
Panel B: Causal factors for DFI gender and location gaps (Decompositions)		
Digital literacy	0.059***	0.112***
	(0.004)	(0.004)
	[71.1%]	[68.3%]
Financial literacy	0.005***	0.005***
	(0.001)	(0.001)

	[6.0%]	[3.0%]
Age	0.007***	-0.010***
	(0.001)	(0.001)
	[%]	[%]
Employed	0.009***	-0.001
	(0.001)	(0.001)
	[%]	[%]
Married	-0.000	-0.004***
	(0.000)	(0.001)
	[%]	[%]
ppi_cutoff	0.007***	0.050***
	(0.001)	(0.003)
	[%]	[%]
Educated	0.015***	0.017***
	(0.001)	(0.001)
	[%]	[%]
Religion	-0.001**	-0.001**
	(0.000)	(0.000)
Observations	15,141	15,141

Notes: A positive (+) sign indicates an advantage for males and urban dwellers while a negative (-) sign shows advantage for females and rural dwellers. Robust standard errors in parentheses while the contributions in percentage terms are shown in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Country-level analysis

Having examined all the objectives at the aggregated level, we now turn our attention to the country-level analysis consisting of Kenya, Nigeria, Tanzania and Uganda where we examine each objective for each country separately.

5.1.1.1. Do the positive effects of digital and financial literacy on DFI hold across all four countries?

First, we focus on the effect of DL and FL on DFI across the countries in Table A3. We present results on this objective across the four countries (Kenya, Nigeria, Tanzania and Uganda) where we highlight four key findings. First, we find that although DL generally improves DFI across all four countries, significant differences exist across gender and location. By gender, we find that in all four countries, except for Kenya, DL benefits females more than males with a differential effect of 0.4 percentage points in Nigeria, 6.2 percentage points in Tanzania and 2.5 percentage points in Uganda in favour of females in these economies. These effects are statistically significant at a one percent alpha level, hence, signalling the relevance of such variations. However, in Tanzania, the effect of DL on DFI is more intense among males relative to females with a differential effect of 0.4 percentage points against females and it is statistically significant at a five percent alpha level. In contrast, the effect of FL on DFI is more pronounced among males compared to females and it holds uniformly across all four countries and the differential magnitude of 1.8 percentage points in Kenya, 0.3 percentage points in Nigeria, 8.1 percentage points in Tanzania and 5.4 percentage points in Uganda all in favour of males statistically significant at five per cent alpha level. In terms of location, DL stimulates DFI across rural and urban areas in all four countries, however, significant heterogeneities exist. Precisely, we find that DL benefits those in urban areas more than those in rural areas with a differential effect of 2.5 percentage points in Kenya, 0.4 percentage points in Nigeria, 5.8 percentage points in Nigeria, 9.8 percentage points in Tanzania, and 4.6 percentage points in Uganda.

Table A3: Effects of digital and financial literacy on DFI by country (Lewbel 2012 estimates)

	(1)	(2)	(3)		(4)	(5)
	Full	Gender			Location	
		Male	Female		Urban	Rural
VARIABLES	DFI	DFI	DFI		DFI	DFI
Panel A: Effects of digital and financial literacy on DFI in Kenya						
Digital literacy	0.351***	0.167***	0.163***		0.025	0.204***
	(0.044)	(0.048)	(0.038)		(0.061)	(0.034)
Financial literacy	0.096**	0.127***	0.109***		0.088**	0.113***
	(0.042)	(0.036)	(0.028)		(0.044)	(0.026)
Individual characteristic?	Yes	Yes	Yes		Yes	Yes
Constant	0.266**	0.456***	0.434*		0.652***	0.263
	(0.135)	(0.154)	(0.229)		(0.178)	(0.220)
Observations	2,680	1,046	1,634		1,074	1,606
F-statistic	35.970***	14.590***	23.340***		6.310***	28.210***
R-squared	0.200	0.213	0.216		0.102	0.253
Panel B: Effects of digital and financial literacy on DFI in Nigeria						
Digital literacy	0.028**	0.020	0.024**	0.060*	0.002	0.028**
	(0.012)	(0.017)	(0.012)	(0.032)	(0.010)	(0.012)
Financial literacy	0.005	-0.005	0.005	-0.030	-0.004	0.005
	(0.015)	(0.030)	(0.013)	(0.039)	(0.012)	(0.015)
Individual characteristic?	Yes	Yes	Yes		Yes	Yes
Constant	0.193***	0.214***	0.196***		0.182***	0.222***
	(0.018)	(0.031)	(0.019)		(0.051)	(0.015)
Observations	4,334	2,279	2,055		1,732	2,602
F-statistic	18.43***	19.94***	18.77***		81.49***	81.18***
R-squared	0.044	0.050	0.033		0.034	0.040
Panel C: Effects of digital and financial literacy on DFI in Tanzania						
Digital literacy	0.383***	0.246***	0.308***	0.435***	0.337***	0.383***
	(0.045)	(0.041)	(0.029)	(0.079)	(0.050)	(0.045)
Financial literacy	0.064	0.196***	0.115***	0.089	0.080	0.064
	(0.048)	(0.032)	(0.023)	(0.080)	(0.051)	(0.048)
Individual characteristic?	Yes	Yes	Yes		Yes	Yes
Constant	0.035	0.206	-0.055		0.117	0.083
	(0.149)	(0.187)	(0.232)		(0.156)	(0.149)
Observations	2,462	1,007	1,455		813	1,649
F-statistic	30.90***	14.09***	28.14***		28.30***	18.07***
R-squared	0.235	0.213	0.271		0.171	0.221
Panel D: Effects of digital and financial literacy on DFI in Uganda						
Digital literacy	0.073***	0.264***	0.289***		0.313***	0.267***
	(0.005)	(0.035)	(0.022)		(0.046)	(0.050)
Financial literacy	0.020***	0.129***	0.075***		0.092**	0.050**
	(0.004)	(0.034)	(0.022)		(0.038)	(0.019)
Individual characteristic?	Yes	Yes	Yes		Yes	Yes
Constant	0.687***	0.067	0.376*		0.300	0.226**
	(0.211)	(0.231)	(0.204)		(0.228)	(0.109)
Observations	2,425	908	1,517		692	1,733
F-statistic	78.57***	28.22***	57.05***		21.18***	36.81***
R-squared	0.395	0.364	0.420		0.375	0.335

Notes: In each model, we controlled for the individual's age, gender, rural-urban location, employment, educational attainment, poverty, marital status and religion. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5.1.1.2. Relative importance of financial and digital literacy to DFI by country

In Table A4 in the appendix, we present the results further assessing the relative importance of digital and financial literacy across the four countries where we pinpoint three key findings. First, across all four countries, digital literacy is the most important predictor of DFI accounting for at least 54.0 percent of the predicted variance in each economy and this holds uniformly across gender and location in all the countries. By gender and location, digital literacy, education and poverty are the most important predictors of DFI among females and those in rural areas in all countries. For males and those in urban settings, it is employment and education.

Table A4: General Dominance by country

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Full		Male		Female		Urban		Rural	
	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank	Dom. Stat.	Rank
Panel A: Kenya										
Digital literacy	0.5603	1	0.5455	1	0.5827	1	0.5967	1	0.5929	1
Financial literacy	0.0239	6	0.0217	7	0.0231	7	0.0233	6	0.0230	7
Male	0.0229	7					0.0282	5	0.0245	6
Urban	0.0366	5	0.0289	5	0.0457	5				
Age	0.0205	8	0.0205	8	0.0362	6	0.0193	7	0.0247	5
Employed	0.0940	4	0.0988	4	0.0871	4	0.1586	2	0.0738	4
Married	0.0083	9	0.0227	6	0.0065	9	0.0090	9	0.0146	8
Poverty	0.1067	3	0.1251	3	0.1009	3	0.0436	4	0.1202	2
Educated	0.1189	2	0.1312	2	0.1066	2	0.1050	3	0.1189	3
Religion	0.0078	10	0.0057	9	0.0112	8	0.0164	8	0.0074	9
Overall Fit Statistic	0.4274		1164		0.4215		0.3357		0.4503	
Observations	3114		0.4266		1950		1203		1911	
Panel B: Nigeria										
Digital literacy	0.6703	1	0.7056	1	0.6807	1	0.7871	1	0.7102	1
Financial literacy	0.0134	8	0.0143	5	0.0101	8	0.0090	7	0.0335	4
Male	0.0481	5					0.0797	2	0.0321	5
Urban	0.0847	2	0.1210	2	0.0518	4				
Age	0.0113	9	0.0133	7	0.0145	6	0.0179	5	0.0107	8
Employed	0.0167	6	0.0133	8	0.0163	5	0.0142	6	0.0320	6
Married	0.0032	10	0.0041	9	0.0090	9	0.0021	9	0.0026	9
Poverty	0.0791	3	0.0638	3	0.1310	2	0.0351	4	0.0860	2
Educated	0.0581	4	0.0505	4	0.0738	3	0.0464	3	0.0752	3
Religion	0.0151	7	0.0141	6	0.0128	7	0.0084	8	0.0177	7
Overall Fit Statistic	0.0587		0.0796		0.0314		0.0888		0.0283	
Observations	5978		2964		3014		2303		3675	
Panel C: Tanzania										

Digital literacy	0.6703	1	0.7056	1	0.6807	1	0.7871	1	0.7102	1
Financial literacy	0.0134	8	0.0143	5	0.0101	8	0.0090	7	0.0335	4
Male	0.0481	5					0.0797	2	0.0321	5
Urban	0.0847	2	0.1210	2	0.0518	4				
Age	0.0113	9	0.0133	7	0.0145	6	0.0179	5	0.0107	8
Employed	0.0167	6	0.0133	8	0.0163	5	0.0142	6	0.0320	6
Married	0.0032	10	0.0041	9	0.0090	9	0.0021	9	0.0026	9
Poverty	0.0791	3	0.0638	3	0.1310	2	0.0351	4	0.0860	2
Educated	0.0581	4	0.0505	4	0.0738	3	0.0464	3	0.0752	3
Religion	0.0151	7	0.0141	6	0.0128	7	0.0084	8	0.0177	7
Overall Fit Statistic	0.0587		0.0796		0.0314		0.0888		0.0283	
Observations	5978		2964		3014		2303		3675	
Panel D: Uganda										
Digital literacy	0.5389	1	0.5922	1	0.4983	1	0.5546	1	0.5949	1
Financial literacy	0.0295	5	0.0303	4	0.0265	5	0.0325	4	0.0301	5
Male	0.0163	8					0.0026	9	0.0365	4
Urban	0.0487	4	0.0197	6	0.0814	4				
Age	0.0203	6	0.0163	8	0.0222	6	0.0266	5	0.0197	7
Employed	0.0186	7	0.0249	5	0.0135	7	0.0180	6	0.0288	6
Married	0.0015	10	0.0190	7	0.0057	9	0.0049	8	0.0011	9
Poverty	0.1546	3	0.1458	3	0.1675	3	0.1335	3	0.1458	2
Educated	0.1672	2	0.1495	2	0.1790	2	0.2177	2	0.1417	3
Religion	0.0043	9	0.0023	9	0.0061	8	0.0095	7	0.0014	8
Overall Fit Statistic	0.5044		0.4871		0.5091		0.4520		0.4699	
Observations	2999		1126		1873		834		2165	

Do digital and financial literacy reduce the inequalities in DFI across all the countries?

Finally, we further investigate the roles of digital and financial literacy in reducing the inequalities in DFI by country and the results are presented in Table A6 in the appendix where we highlight three key findings. First, in terms of the DFI gender gap (see Panel A of Table A5 in appendix), we find that Nigeria has the highest gap of 17.1 percentage points, followed by Tanzania 12.7 percentage points, Uganda (11.2 percentage points) and Kenya with the lowest gap of 7.2 percentage points. Moreover, across the four countries, we find that a significant portion of the DFI gender gap is largely due to differences in endowment between males and females. Remarkably, in Kenya, Tanzania and Uganda, improving females' opportunities/endowments on par with their male counterparts is more than enough to close the existing DFI gender gaps. However, in Nigeria equalising the differences in opportunities or endowments between males and females will reduce the existing DFI gender gap by 50.3 percent. In Panel B of Table A6, we find that across all the countries studied, digital and financial literacy contribute to over half of the DFI gender gaps with digital literacy leading. Precisely, digital literacy accounts for nearly 54.0 percent, 47.0 percent, 77.0 percent and 92.0 percent of the DFI gender in Kenya, Nigeria, Tanzania and Uganda respectively. Regarding financial literacy, it contributes about 6.0 percent, 7.4 percent and 5.2 percent of the DFI gender gap in Kenya, Nigeria and Tanzania but in Uganda, its contribution is almost zero.

Regarding DFI location gaps (see Panel A of Table A6), we find the highest gap in Nigeria (30.8 percentage points), followed by Uganda (27.2 percentage points), Tanzania (24.8 percentage points) and Kenya (10.0 percentage points). Further, we find that across the countries studied, the DFI location inequalities are largely attributed to differences in endowments. Thus, improving females' opportunities on par with their male counterparts with reduced the DFI location gap by 93.0 percent, 46.4 percent, 61.3 percent, and 73.2 percent in Kenya, Nigeria, Tanzania and Uganda respectively. In terms of causal factors of the gap (see Panel B of Table, digital literacy accounts for over 113.0 percent of the gap in Kenya, almost 38.0 percent in Nigeria, 88.0 percent in Tanzania and 84.1 percent in Uganda.

Table A5: Digital literacy questions and proportion of correct answers

	(1)	(2)	(3)	(4)	(5)
	Pooled	Kenya	Nigeria	Tanzania	Uganda
Make and receive calls	0.900	0.974	0.870	0.938	0.840
Navigate the menu on the phone	0.781	0.914	0.783	0.677	0.738
Send and receive text messages	0.708	0.857	0.676	0.755	0.561
Use the internet	0.412	0.590	0.406	0.362	0.278
Has the ability to open a mobile money menu	0.290	0.734	0.014	0.346	0.325
Has the ability to find a particular menu option (e.g., an option for a money transfer)	0.276	0.722	0.015	0.315	0.296
N	15232	3129	6042	3060	3001

Notes: For each question, a respondent has four response options: (1) No ability (2) a little ability (3) some ability (4) complete ability. Thus, a respondent is said to have ability when he has at least a little ability to perform the activity and 0 otherwise.

Table A6: Financial literacy questions and corresponding proportion of correct answers (correct answer in bold)

	(1)	(2)	(3)	(4)	(5)
	Pooled	Kenya	Nigeria	Tanzania	Uganda
Imagine you have $200. Somebody gave you $100. How much total money will you have? Option: **(A) $300** , (B) Any other answer, (C) Don't Know	0.910	0.949	0.966	0.774	0.898
Imagine you have $100 and you have to divide it among 5 people. How much money will each person receive if you divide it equally? Option: (**A) $20** , (B) Any other answer, (C) Don't Know	0.808	0.874	0.932	0.817	0.481
Is it safer to put your money into one business or investment, or to put your money into multiple businesses or investments? Option: (A) One business or investment, **(B) Multiple businesses or investments**, (C) Don't Know	0.582	0.566	0.520	0.679	0.624
Suppose over the next 10 years the prices of the things you buy double. If your income also doubles, will you be able to buy less than you can buy today, the same as you can buy today, or more than you can buy today? Option: (A) Less, **(B) The same**, (C) More (D) Don't Know	0.375	0.422	0.417	0.282	0.335
Suppose you need to borrow $100. Which is the lower amount to pay back: $105 or $100 plus 3 percent? Option: (A) $105, **(B) $100 plus 3 percent**, (C) Don't Know	0.398	0.418	0.435	0.392	0.309
Suppose you put money in the bank for two years and the bank agrees to add 15 percent per year to your account. Will the bank add more money to your account the second year than it did the first year, or will it add the same amount of money both years? Option: (A) The same, **(B) More** (C) Don't Know	0.291	0.353	0.300	0.245	0.253
Suppose you had $100 in a savings account and the bank adds 10 percent per year to the account. How much money would you have in the account after five years if you did not remove any money from the account?	0.191	0.168	0.297	0.094	0.102

Option: (A) Exactly $150 , **(B) More than $150 local current** (C) Less than $150 (D) Don't Know					
N	15232	3129	6042	3060	3001

Table A7: Indicators of Digital financial inclusion

	(1)	(2)	(3)	(4)	(5)
	Pooled	Kenya	Nigeria	Tanzania	Uganda
	Mean	Mean	Mean	Mean	Mean
Electronic banking					
Savephone indicates whether the respondent saves using a mobile phone linked to a Bank account (Dummy: Yes=1, No=0)	0.191	0.453	0.029	0.229	0.203
digrecharge indicates whether the respondent uses a digital/recharge for shopping (Dummy: Yes=1, No=0)	0.010	0.015	0.012	0.003	0.008
Savedigrecharge indicates whether the respondent saves using a digital card/recharge card (Dummy: Yes=1, No=0)	0.008	0.021	0.007	0.000	0.004
VSLdigit indicates whether the respondent's savings and loans group is linked to a mobile money account	0.021	0.061	0.004	0.011	0.023
Mobile money banking					
Momoacct: indicates whether the respondent owns a mobile money account (Dummy: Yes=1, No=0)	0.358	0.741	0.026	0.540	0.440
Savemomophone indicates whether the respondent saves using a Mobile money account (Dummy: Yes=1, No=0)	0.204	0.527	0.010	0.214	0.249
Mdepositwith indicates whether the respondent deposits/withdraws using mobile money (Dummy: Yes=1, No=0)	0.350	0.778	0.016	0.458	0.467
Mairtime indicates whether the respondent buys airtime using mobile money account (Dummy: Yes=1, No=0)	0.265	0.634	0.014	0.356	0.291
Mschfees indicates whether the respondent pays school fees using mobile money account (Dummy: Yes=1, No=0)	0.029	0.092	0.005	0.019	0.022
Mmedical indicates whether the respondent pays a bill for medical expenses, housing, rent or utilities, such as electricity, water, solar, satellite TV or cable TV using mobile money (Dummy: Yes=1, No=0)	0.075	0.194	0.005	0.090	0.075
Mgovtbill indicates whether the respondent pays a government bill, including tax, fine or fee using mobile money account (Dummy: Yes=1, No=0)	0.008	0.020	0.003	0.010	0.003
Mfaimly indicates whether the respondent send money to, or received money from, family members, friends, workmates or other acquaintances using mobile money (Dummy: Yes=1, No=0)	0.268	0.616	0.011	0.354	0.336
Mwelfare indicates whether the respondent receives a welfare, pension or other benefit payment from the government using mobile money (Dummy: Yes=1, No=0)	0.005	0.011	0.002	0.004	0.005
Mwages indicates whether the respondent receives wages for your primary or secondary job through mobile money (Dummy: Yes=1, No=0)	0.042	0.141	0.004	0.022	0.035
Minsuranc indicates whether the respondent makes insurance payments or receives claims on insurance using mobile money (Dummy: Yes=1, No=0)	0.007	0.026	0.002	0.004	0.001
Mloan indicates whether the respondent takes loans or makes payments on a loan using mobile money (Dummy: Yes=1,	0.030	0.106	0.002	0.028	0.007

No=0)					
Minvest indicates whether the respondent makes investment, including bought stock or shares using mobile money	0.008	0.019	0.002	0.009	0.005
Mshop indicates whether the respondent pays for goods or services at a grocery store, clothing shop or any other store/shop using mobile money (Dummy: Yes=1, No=0)	0.038	0.130	0.005	0.027	0.019
N	15232	3129	6042	3060	3001

Table A8: Results for digital literacy index using the Principal-component factors method

Factor	Eigenvalue	Difference	Proportion	Cumulative
Panel A: Eigen values				
Factor1	3.12220	1.84174	0.5204	0.5204
Factor2	1.28045	0.55044	0.2134	0.7338
Factor3	0.73001	0.33527	0.1217	0.8554
Factor4	0.39474	0.03472	0.0658	0.9212
Factor5	0.36002	0.24745	0.0600	0.9812
Factor6	0.11258	.	0.0188	1.0000
Panel B: Retain factors				
Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.33595	0.26926	0.3893	0.3893
Factor2	2.06669	.	0.3444	0.7338
Overall KMO	0.8149			

Notes: KMO refers to Kaiser-Meyer-Olkin sampling adequacy tests where a score of 0.815 is deem meritorious (Kaiser,1974)

Table A9: Results for financial literacy index using the Principal-component factors method

Factor	Eigenvalue	Difference	Proportion	Cumulative
Panel A: Eigen values				
Factor1	1.59087	0.44986	0.2273	0.2273
Factor2	1.14101	0.11282	0.1630	0.3903
Factor3	1.02820	0.09794	0.1469	0.5372
Factor4	0.93025	0.10717	0.1329	0.6700
Factor5	0.82308	0.04558	0.1176	0.7876
Factor6	0.77750	0.06841	0.1111	0.8987
Factor7	0.70909	.	0.1013	1.0000
Panel B: retained factors				
Factor	Variance	Difference	Proportion	Cumulative
Factor1	1.35478	0.07305	0.1935	0.1935
Factor2	1.28173	0.15815	0.1831	0.3766
Factor3	1.12358	.	0.1605	0.5372
Overall KMO	0.8030			

Notes: KMO refers to Kaiser-Meyer-Olkin sampling adequacy tests where a score of 0.800 is deem meritorious (Kaiser,1974)

Table A10: Results for DFI index using the Principal-component factors method

Factor	Eigenvalue	Difference	Proportion	Cumulative
Panel A: Eigenvalues				
Factor1	4.66553	2.89419	0.2744	0.2744
Factor2	1.77134	0.61871	0.1042	0.3786
Factor3	1.15262	0.11654	0.0678	0.4464
Factor4	1.03608	0.08890	0.0609	0.5074
Factor5	0.94719	0.08975	0.0557	0.5631
Factor6	0.85744	0.02767	0.0504	0.6135
Factor7	0.82976	0.02464	0.0488	0.6624
Factor8	0.80512	0.03409	0.0474	0.7097
Factor9	0.77104	0.01386	0.0454	0.7551
Factor10	0.75717	0.03236	0.0445	0.7996
Factor11	0.72481	0.03990	0.0426	0.8422
Factor12	0.68491	0.06987	0.0403	0.8825
Factor13	0.61505	0.13975	0.0362	0.9187

Factor14	0.47530	0.09651	0.0280	0.9467
Factor15	0.37879	0.05979	0.0223	0.9689
Factor16	0.31900	0.11014	0.0188	0.9877
Factor17	0.20885	.	0.0123	1.0000
Panel B: Retained factors				
	Variance	Difference	Proportion	Cumulative
Factor1	3.95302	2.17662	0.2325	0.2325
Factor2	1.77640	0.11985	0.1045	0.3370
Factor3	1.65655	0.41695	0.0974	0.4345
Factor4	1.23960	.	0.0729	0.5074
Overall KMO	0.899			

Notes: KMO refers to Kaiser-Meyer-Olkin sampling adequacy tests where a score of 0.90 is deem mavelous (Kaiser,1974)

Table A11: Additional hypothesis testing results on digital literacy

Null hypothesis	KS statistic	95% critical value
No effect	42.400	3.007
Constant effect	21.174	2.511
Dominance	4.230	3.329
Exogeneity	3.576	2.566

Rule of thumb: Reject the null hypothesis if the test statistic is greater than the critical value

Table A12: Additional hypothesis testing results on financial literacy

Null hypothesis	KS statistic	95% critical value
No effect	14.568	2.962
Constant effect	8.913	2.826
Dominance	0.000	2.892
Exogeneity	5.073	2.738

Rule of thumb: Reject the null hypothesis if the test statistic is greater than the critical value

Table A13: Full results for the effects of DL and FL in narrowing DFI gender and location gaps (Fairlier's Approach)

VARIABLES	(1) DFI	(2) DFI
DL	0.049***	0.114***
	(0.001)	(0.002)
FL	0.003***	0.004***
	(0.001)	(0.001)
urban	-0.001***	
	(0.000)	
age	0.014***	-0.007***
	(0.001)	(0.000)
employ	0.009***	-0.002***
	(0.001)	(0.000)
married	-0.000*	-0.003***
	(0.000)	(0.001)
ppi_cutoff	0.003***	0.052***
	(0.000)	(0.003)
eduhigher	0.020***	0.019***
	(0.001)	(0.001)
religion	-0.001***	-0.000***
	(0.000)	(0.000)
Country1	-0.000	0.000
	(0.001)	(0.000)
Country2	-0.000***	0.001***
	(0.000)	(0.000)
Country3	-0.010***	0.000
	(0.001)	(0.000)
Country4	0.000	-0.000
	(0.000)	(0.000)
male		-0.000*
		(0.000)
Observations	15,141	15,141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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