Recalibrating the scope of financial inclusion through financial technologies in the digital age: the role of digital literacy as a moderator in rural Uganda

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Abstract

Purpose – The main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies (FinTechs) of biometrics and mobile money and digital financial inclusion among the unbanked poor women, youth and persons with disabilities (PWDs) in rural Uganda.

Design/methodology/approach – Covariance-based structural equation modeling was used to construct the interaction effect using data collected from the unbanked poor women, youth and PWDs located in the four regions in Uganda as prescribed by Hair *et al.* (2022).

Findings – The findings from this study are threefold: first; the results revealed a positive interaction effect of digital literacy between FinTechs of biometrics and mobile money and digital financial inclusion. Second; the results also confirmed that biometrics identification positively promotes digital financial inclusion. Lastly; the results showed that mobile money positively promotes digital financial inclusion. A combination of FinTechs of biometrics and mobile money together with digital literacy explain 29% variation in digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

Research limitations/implications – The data for this study were collected mainly from the unbanked poor women, youth and PWDs. Further studies may look at data from other sections of the vulnerable population in under developed financial markets. Additionally, the data for this study were collected only from Uganda as a developing country. Thus, more data may be obtained from other developing countries to draw conclusive and generalized empirical evidence. Besides, the current study used cross sectional design to collect the data. Therefore, future studies may adopt longitudinal research design to investigate the impact of FinTechs on digital financial inclusion in the presence of digital literacy across different time range.

Practical implications – The governments in developing countries like Uganda should support women, youth, PWDs and other equally vulnerable groups, especially in the rural communities to understand and use FinTechs. This can be achieved through digital literacy that can help them to embrace digital financial services and competently navigate and perform digital transactions over digital platforms like mobile money without making errors. Besides, governments in developing countries like Uganda can use this finding to advocate for the design of appropriate digital infrastructures to reach remote areas and ensure "last mile connectivity for digital financial services' users."

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The use of off-line solutions can complement the absence or loss of on-line network connectivity for biometrics and mobile money to close the huge digital divide gap in rural areas. This can scale-up access to and use of financial services by the unbanked rural population.

Originality/value – This paper sheds more light on the importance of digital literacy in the ever complex and dynamic global FinTech ecosystem in the presence of rampant cyber risks. To the best of the authors' knowledge, limited studies currently exist that integrate digital literacy as a moderator in the relationship between FinTechs and digital financial inclusion, especially among vulnerable groups in under-developed digital financial markets in developing countries. This is the novelty of the paper with data obtained from the unbanked poor women, youth and PWDs in rural Uganda.

Keywords Mobile money, Digital literacy, Biometrics identification, Financial technology, Digital financial inclusion, Digital financial services

Paper type Research paper

1. Introduction

Presently, with the upsurge in financial technologies (FinTechs), the traditional banking system has fallen behind the curve within the global financial market's landscape. McKinsey Global Institute estimates that digital finance through FinTech revolution could add up to over $3.7 trillion to the global domestic product (GDP) of developing economies by the year 2025.

According to the United Nations (2015), ensuring universal access to and use of financial services among the unbanked and underserved population like those at the "bottom of the pyramid" in developing countries where financial exclusion looms large, can help to reduce poverty incidences and spur growth (see also World Bank, 2020; Beck *et al.*, 2007). Okello Candiya Bongomin *et al.* (2023) contend that availability of wide range of financial services is vital for economic well-being of the poor in developing countries like Uganda because it economically and socially empower them to generate income, build assets, smooth consumption, and manage risk.

Regrettably, the unbanked and underserved "bottom of the pyramid" population remains unserved by the traditional banking system in developing countries (Beck, 2020). Predominantly, the traditional banks always require prospective customers to meet certain terms and conditions to use financial services that they offer within the financial market. Beck *et al.* (2008) show that the terms and conditions on use of financial services offered by banks such as account opening fees, minimum account balance, collateral requirement, identification requirement and stringent loan terms are the main barriers to access to and use of banking services in developing countries. Fafchamps (2013) further observes that collateral requirement constraints access to credit by the poor to invest and escape from poverty. In the same vein, Ozili (2018) also states that some poor individuals may voluntarily exclude themselves because they may not need to deal directly with the banks or the services offered may not suit their needs. Consequently, all these have resulted into voluntary and involuntary exclusion of the poor from the main stream financial system (Beck *et al.*, 2015).

Worth noting, while the poor individuals in developing countries remain without access to and use of basic financial services due to price and non-price barriers, most of them own mobile phones that can offer opportunities for digital banking (Maurer, 2012).

Ehrentraud *et al.* (2020) argue that the FinTech sector can support economic growth and reduce financial exclusion by providing access to financial services through mobile phones. Suri (2017), Suri and Jack (2016), Lauer and Lyman (2015) also show that FinTechs through digital finance can revolutionize access to financial services among low income households. FinTechs can provide digital financial services at reduced costs with convenience to users, making it profitable for providers to serve a larger range of customers (Venet, 2019).

Specifically, the World Bank Identification for Development Initiative (2018) states that use of FinTechs like biometrics identification make it easier to open a transaction account for the poor who do not have formal identity documents. Biometrics can facilitate delivery of basic financial services to the unbanked and underserved population in a cost-effective

manner. Besides, Shaw (2021) argues that mobile money can offer easy and convenient means through which the poor can remotely access and use varieties of financial services at reduced costs as compared to the traditional banks. Mobile telephony with its ubiquity can help the formally unbanked and underserved poor population to cheaply and safely access and use financial services without the need for a bank account.

Nonetheless, whilst FinTech remains a buzz word as a contemporary conduit for promoting an inclusive financial system globally, limited empirical evidence exist on the interaction between digital literacy and adoption and use of biometrics and mobile money, especially in developing countries. Besides, the Organization for Economic Co-operation and Development (2020) estimates that the level of digital literacy remains unacceptably low among the vulnerable sections of the population like women, youth and persons with disabilities (PWDs), especially in developing countries. For example, the Uganda Communications Commission Annual Report (2020) shows that about 52% of the population that correspond to 24.4 million people in Uganda are digitally illiterate, a great number of which are the rural poor individuals. In addition, a study by Federation of Small and Medium Sized Enterprises in Uganda (2018) also revealed that about 72% of the MSMEs generally suffer from digital skills gap. This has partly hindered financial inclusion, especially among the vulnerable and unbanked population like the women, youth and PWDs who suffer from extreme exclusion from the formal financial system.

Accordingly, the Organization for Economic Co-operation and Development-OECD (2020) proposes that the underserved and unbanked poor population in developing countries, who are presumed illiterate, have to be equipped with skills to be able to competently use the new breed of FinTech tools in order to embrace its tremendous potential in increasing access to and use of financial services.

Studies such as Prete (2022), Kass-Hanna *et al.*, (2022), Abdulquadri *et al.*, (2021), and Yoshino *et al.*, (2020) among others, suggest that digital literacy can help the unbanked and underserved poor population to acquire knowledge about digital financial products and services and to become aware of digital financial risks, risk control strategies, and knowledge of consumer rights and redress procedures while dealing over the FinTech ecosystem. This can increase access to and use of basic financial services by the poor population in developing countries (see, e.g. Morgan *et al.*, 2020).

Thus, in light of the above trajectories, the dearth in empirical evidence, literature, and theory on whether digital literacy can enhance the use of FinTech tools to spur financial inclusion among the vulnerable unbanked and underserved population like the women, youth and PWDs, especially in rural Uganda, is the benchmark for this study.

Therefore, the main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies of biometrics and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

The main research question is: do financial technologies of biometrics and mobile money promote digital financial inclusion of the unbanked poor women, youth and PWDs in under developed digital financial markets in developing countries like Uganda in the presence of digital literacy? This study is guided by the suggested conceptual model in Figure 1.

2. Literature review

2.1 Financial technologies and digital financial inclusion

According to the World Bank (2020), access to finance is often cited as a key factor for sustainable poverty alleviation in developing countries. The Organization for Economic Co-operation and Development-OECD (OECD, 2018) contends that access to and use of financial services play a critical role in supporting inclusive and sustainable development. The availability of financial services to the unbanked and underserved population, who are mostly the poor, helps them to generate income to improve on the standard of living in their particular households.

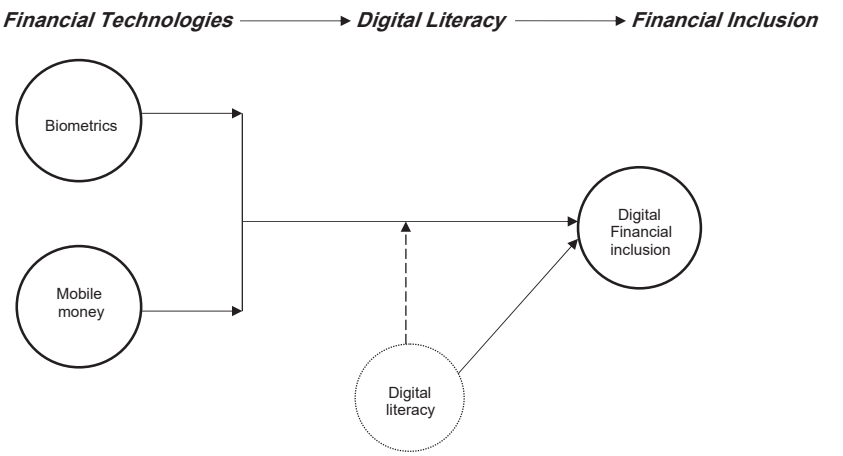


Figure 1.
Suggested conceptual study model

Source(s): Author(s) own creation/work

However, expanding access to financial services, especially to the poor has always remained a challenge for providers in most parts of the developing world sub-Saharan Africa inclusive. Although remarkable progress has been registered towards the financial inclusion agenda prescribed under the Sustainable Development Goals to be achieved by the year 2030, Demirgüç-Kunt *et al.* (2018) estimate that about 1.7 billion adults worldwide still do not have a basic account at a financial institution or at a mobile money provider. This is because of high transaction cost, information asymmetry, insufficient credit records, lack of formal documentations, and shortage of collateral. This implies that there is persistent upward poverty trends since most poor households still remain without access to and use of safe and reliable means to save, borrow, make payments, invest, and insure against risk. This negatively affects their livelihood, productivity, and growth, which harbors inequality (World Bank, 2007).

For that reason, the Global Systems for Mobile Communications-GSMA (2020) demonstrates that FinTechs can offer a better solution to transform the means by which financial services can be provided to the unbanked and underserved poor population in under developed financial markets in developing countries like Uganda.

Wang and He (2020) argue that FinTechs such as biometrics and mobile money can help the unbanked and underserved population like the poor women, youth and PWDs to access varieties of services like digital payments, digital investments, and digital financing at an affordable cost than that provided by the traditional banks.

Ozili (2018) further notes that FinTechs can provide affordable, responsive, and secure banking services to the unbanked poor people. Specifically, mobile money can offer the unbanked individuals access to user-friendly, cheap, and well-suited financial products for safe money storage, payment of bills, and money transfers. Digital technologies can help to address the eligibility and affordability barriers, which are the main impediments to financial inclusion of the poor in developing countries. Hence, we derive the hypothesis that:

H1. Financial technologies significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

2.2 Biometrics identification and digital financial inclusion

Globally, the identification system plays a significant role in enabling financial inclusion of individuals. Availability of a unique and legal identity is necessary to allow all individuals to

participate fully in the society and the economy to gain access to formal services including financial services (OECD, 2018).

Particularly, within the financial sector, verification of identity helps the financial services' providers to facilitate registration, minimize the risk of fraud, and meet the requirements for customer due diligence regulations to prevent money laundering and terrorist financing (Financial Action Task Force, 2017, 2013).

Nevertheless, the World Bank (2022) approximates that over 1 billion people around the world still lack an officially recognized proof of identity. Beck *et al.* (2008) also confirm that most poor individuals who reside and operate in rural areas in developing countries are unable to provide a reliable form of identification that can meet customer due diligence requirements to open a formal bank account. Yet they are in dire need of basic financial services to move out of poverty.

Thus, the World Bank (2018a, b) suggests that use of FinTech tools like biometrics for identification purpose, can increase access to and use of financial services among the poor by easing identification requirement. New digital approaches such as biometrics can allow the unbanked poor individuals to instantly have access to identification services in a more effective way in order to gain access to and use financial services.

Furthermore, the Bank for International Settlements (2016) also indicates that use of biometrics can potentially lead to more adoption of digital financial services, especially by the poor who do not have formal identity documents. Biometrics make it easier for the unbanked and underserved population like the poor to open a transaction account, enable more cost-effective and remote customer on-boarding, and facilitate the delivery of additional financial services. Duflo and Udry (2004) contend that digital identification (ID) technology can be instrumental in ensuring access to financial services in order to empower the vulnerable poor individuals to come out of poverty.

Indeed, the biometrics identification system rapidly registers, prevents duplication, and verifies the identities of individuals whether they have an identification document or not. This helps to solve the challenge of lack of identification while accessing and using financial services to avoid fraud. Biometrics identification can enhance the security credentials and potentially makes it a more secure process to enable financial inclusion among the unbanked and underserved poor population like the women, youth and PWDs while meeting regulatory requirements of anti-money laundering/countering financing terrorism. Marron (2013) found that use of an iris recognition system linked to automated teller machine with a specialized iris camera helped more than a third of the unprecedented 630,000 Syrian refugees to access monthly cash assistance through Cairo Amman Bank. Thus, we suggest the hypothesis that:

H1a. Biometrics identification significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

2.3 Mobile money and digital financial inclusion

According to Beck *et al.* (2008), majority of the unbanked and underserved poor individuals, especially in developing countries remain without access to and use of financial services because of cost and geographical barriers.

Okello Candiya Bongomin *et al.* (2022) suggest that mobile money can leverage cost and geographical barriers in terms of distance, which results into increased financial inclusion of the poor who live in geographically dispersed rural areas in developing countries like Uganda.

More so, Manyika *et al.* (2016a, b) also observe that mobile money can increase access to and use of financial services by the unbanked poor individuals because it is affordable and can invent and offer new products at reduced cost. Lyman and Lauer (2015) concur that mobile money can yield additional benefits for financial inclusion by providing the poor with

access to additional financial services such as interest-bearing savings, credit, insurance, and investment products. Additionally, Beck *et al.* (2018) observe that mobile money can provide users with a cheaper and safer money transfer tool to carry and share liquidity with mobile phones due to its convenience in risky environments.

Similarly, Hussein (2020) asserts that mobile phones enable customers to make or receive payments, transfer money less expensively, and safely store value electronically with a bank or non-bank permitted to store electronic value. This can reduce the risk of loss, theft, and other financial crimes related to cash transactions.

Kamande *et al.* (2021) further attest to the fact that mobile money can also provide transaction records that can be used by the unbanked poor individuals when applying for loans since they have limited collateral and cannot convincingly prove repayment capacity because of the problem of information asymmetry. A typical case in point is the M-Shwari consumer loans offered by Commercial Bank of Africa to M-PESA customers in Kenya.

Furthermore, Wang and He (2020) also argue that by being more suitable for the unbanked poor who have very small and unpredictable cash flows, mobile money can accommodate and allow them to transact affordably in tiny amounts whenever they wish, subject to the vagaries of unpredictable or unreliable connections and other risks.

Therefore, it can be deduced that since mobile telephony network coverage remains generally high with fast growing phone subscriptions and Smartphone ownership in rural areas in developing countries, mobile money offers the most reliable digital channel to expand affordable, effective, and safe financial services to the currently 1.7 billion unbanked adults globally. Therefore, we state the hypothesis that:

H1b. Mobile money significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

2.4 Digital literacy and digital financial inclusion

According to the Americans for Community Co-operation in Other Nations-ACCION (2011), financial inclusion is defined as "a state in which all people who can use them have access to a full suite of quality financial services provided at affordable prices, in a convenient manner, and with dignity for the clients". While Lyman and Lauer (2015) refers to digital financial inclusion as "digital access to and use of formal financial services by excluded and underserved populations". Thus, digital financial services should be suited to the needs of customers and delivered responsibly at affordable cost to the customers and sustainable for providers.

Recently, digital financial inclusion became famous and attracted global attention as a result of the success of M-PESA revolution in 2007 in Kenya. The M-PESA innovation was initially curved from an idea where individuals would load airtime for relatives in distant places who in turn received cash from the phone owner (Aker and Wilson, 2013).

However, the Consultative Group to Assist the Poor – CGAP (2015) observes that the presence of different participants with diverse roles within the mobile money ecosystem introduces and exposes users to operational, consumer-related, and financial crimes among others.

Accordingly, the OECD (2020) suggests that digital literacy can help the financially excluded and underserved poor population who are susceptible to risk and frauds to be prepared to make the right decisions before consuming digital financial products. Digital literacy enables the poor to acquire skills that they can use to fully take advantage of the opportunities and minimize the risks brought by FinTech.

Yoshino *et al.* (2020) also argue that digital literacy can help the poor to analyze simple instructions on the functioning of digital financial products and plain indications on where to obtain more information and how to get recourse on mistakes made over the FinTech platforms. This can ensure safe digital financial environment, which can lead to more uptake and use of digital financial services, hence, increased digital financial inclusion.

Relatedly, the OECD (2020) observes that digital literacy can reduce digital divide among the educated and illiterate consumers of digital financial services. This can result into increased access and use of digital financial services by the unbanked and underserved individuals from all sections of the population. Digital literacy can give the poor sophistication to process financial information before consuming digital financial products. Thus, the poor may be attracted to continue consuming such products, hence, increased digital financial inclusion.

Medhi *et al.* (2009) discovered that low levels of numerical literacy, unavailability of options in local languages, lack of familiarity with banking jargon, and application complexity made mobile money users in India, Kenya, Philippines, and South Africa to rely on agents to fulfill their transactions. This justifies the need for digital literacy among the illiterate population like the poor women, youth and PWDs who live in rural areas in developing countries. As a result, we argue out the hypothesis that:

H2. Digital literacy significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

2.5 Digital literacy: moderator between financial technologies and digital financial inclusion

According to the GSMA (2020), the rapid technological development through digital solution has influenced the functioning of the economic world by increasing access to financial services, especially in the unbanked and underserved global societies.

Scholars like Alameda (2020), Milan (2019), Salampasis and Mention (2018) argue that FinTech can provide a promising medium by which the financially excluded individuals can have access to and use of financial services previously inaccessible from the incumbent financial institutions at lower cost.

However, while FinTech can promote financial inclusion by allowing access to banking services to the majority financially excluded population, its use requires some level of competence to effectively perform transactions.

Digital literacy helps the poor to compare different financial products available on the market before consuming them to ensure that they suit their needs in terms of cost and reliability (OECD, 2020). This can result into increased consumption of suitable digital financial products by the unbanked and underserved poor households, hence, increased financial inclusion.

Prete (2022) also observes that digital literacy can allow individuals like the unbanked poor women, youth and PWDs to acquire skills needed to become digitally proficient to use digital technology, communication tools, and networks to obtain and evaluate information, communicate with others, and perform digital transactions in technology-rich environment.

Abdulquadri *et al.* (2021) further state that digital literacy can help individuals like the unbanked poor women, youth and PWDs to acquire skills to effectively communicate through innovative channels such as chatbots to ask questions, make verifications, and privately provide personal information through proper engagement on digital financial issues. Digital literacy can boost customers' ability to engage with chatbots used by digital financial services' providers to securely make inquiries and meet their financial needs.

Besides, Saini (2019) observes that digital literacy can help the poor to analyze digital credit provided by FinTech in order to make better choices to avoid the problem of over borrowing, excessively high interest rates, and over-indebtedness. Digital literacy can help the poor women, youth and PWDs to understand the terms and conditions stated on digital contracts before signing to avoid risky implications. This can promote better loan repayment, which presents the borrowers with future opportunities to access high amount of digital credit from the providers.

Furthermore, digital literacy can also enable the poor to understand the risks that they may incur when using digital financial services. Specifically, digital literacy can provide the poor with abilities to evaluate fraud and cyber security risks such as phishing, pharming, spyware, and SIM card swaps linked to use of digital financial products (Banco de Portugal, 2018).

Finally, the World Bank (2016) indicates that through digital literacy, the unbanked individuals such as women, youth and PWDs can understand their rights regarding personal data and how they can obtain redress against unauthorized use. The knowledge and awareness about data protection and the right of data use can persuade them to use digital financial services that result into financial inclusion. Digital literacy safeguards new users from financial predation and makes it easy for them to use financial products offered through mobile phones.

Kass-Hanna *et al.* (2022) used data drawn from the InterMedia Financial Inclusion Insights surveys for seven South Asian and Sub-Saharan African countries to investigate the impact of multi-dimensional measures of financial and digital literacy on resilience-building financial behaviors, including saving, borrowing, and risk management among poor women living in rural areas. The results revealed that increase in financial and digital literacy levels are associated with increase in savings, borrowings, and risk management for those dealing with Non-Bank Financial Institutions or mobile money service providers. Accordingly, we state the hypothesis that:

H3. Digital literacy significantly and positively moderate the relationship between financial technologies and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

3. Methodology and research tool

3.1 Study design

This study adopted cross-sectional research design combined with both analytical and descriptive approaches to collect data and generate the results. This particular design was used specifically because of its superiority to elicit large amount of data from samples located in dispersed areas. Additionally, this design does not suffer from unavailability of samples in follow-up studies common with longitudinal design. Besides, it does not suffer from recurrent mistakes in the study instruments since it elicit responses from the selected respondents at a specific point in time. Furthermore, this design can also be the most suitable in studies using heterogeneous measurement scales that are useful for disrupting consistency biases and increasing validity (Rindfleisch *et al.*, 2008; Bearden and Netemeyer, 1998).

3.2 Population and sample size

The population for this study was selected from 458,106 businesses located in four regions (northern, central, eastern, and western) in Uganda using the database of Census of Business Establishments in Uganda by Uganda Bureau of Statistics (Uganda Bureau of Statistics, 2010/2011). The Report showed that about 90% of the businesses were MSMEs owned by poor women, youth and PWDs. The Ministry of Finance, Planning and Economic Development in Uganda (2002) defines a poor person as "an individual who faces the situation of poor health, low level of income and consumption, unemployment, illiteracy, low level of production, physical insecurity, disempowerment, and isolation socially and geographically". Consequently, a total population of 412,300 comprising of women, youth, and PWDs' owned MSMEs was used in this study. The formula derived from Yamane (1973) was used to select the appropriate sample size for this study. The sample size was arrived at using the formula: $n = [N/1 + N (e)2]$. Thus, a total sample of 399 women, youth and PWDs' owned MSMEs located in the four regions in Uganda was used in this study.

3.3 Sampling design and procedures

The sampling for this study was done at two levels: First, purposive sampling was used to select only poor women, youth and PWDs owned MSMEs. Second, simple random sampling was used to select individual poor women, youth and PWDs owners/managers of the MSMEs

to participate in this study. The selected MSMEs owners/managers for this study were assigned unique identification numbers, which were used during data collection exercise. This helped to eliminate the problem of double responses from the sampled respondents. Overall, a total of 399 responses were collected from poor women, youth and PWDs owned MSMEs located in the four regions in Uganda identified for this study.

3.4 Data collection instruments and process

A semi-structured questionnaire was used to collect data for this study. This is because of its strength in collecting both closed and open-ended responses from the selected samples. The items in the questionnaire were put on a 5-point Likert scale to collect responses from the selected respondents. This scale was used because of its simplicity, clarity, and versatility (DeVellis, 2003; Likert, 1932; Johns, 2010). Four research assistants located in the four different regions in Uganda collected the data for this study using Kobocollect remote digital data collection platform. The data collection exercise lasted for a period of one month from April 8th to May 8th 2021.

3.5 Measurements of research variables

The measures for the different variables under this study were developed and adopted from previous studies published in internationally referenced journals since they were found to be reliable and valid to be used in future studies.

Financial technologies, which included biometrics identification and mobile money were measured using 25 items. Biometrics identification was measured using 11 items developed from Appaya and Varghese (2019) and Manisha *et al.* (2018). Mobile money was measured using 14 items adopted from Okello Candiya Bongomin *et al.* (2020), Suri and Jack (2016), Munyegera and Matsumoto (2018), Aker *et al.* (2016).

Digital literacy was measured using 19 items developed from Kass-Hanna *et al.* (2022), Morgan *et al.* (2019), Chetty *et al.* (2017).

Digital financial inclusion was measured using 16 items adopted from Okello Candiya Bongomin and Munene (2019), Okello Candiya Bongomin *et al.* (2016), Demirgüç-Kunt *et al.* (2018), Alliance for Financial Inclusion (2018), Čihák *et al.* (2012). All the items were scored on a scale of: (5) strongly agree; (4) agree; (3) uncertain (2) disagree; (1) strongly disagree.

The test for reliability and validity were conducted on the measurement scale items. The results indicated that all the items had Cronbach's Alpha coefficients above 0.7 recommended by Nunnally and Bernstein (1994). The content validity index through expert views and constructs validity tests were all tenable as recommended by Amin (2005), Creswell (2006), Hair *et al.* (2016). The measurement items for all the variables are presented in Table 1.

3.6 Parametric test

The test for parametric assumptions is performed on the data to check whether they are normally distributed and good for further statistical analysis (Field, 2005). The test for parametric assumption using normality was performed on the data collected from the field. The histogram and scatter plots were used to test whether the data were normally distributed. The results of all the tests were significant and positive. In addition, the test for multi-collinearity was also performed on the data using variance inflation factor (VIF) and tolerance factor. The results showed that the VIF and tolerance factor figures achieved the rule of thumb thresholds.

3.7 Moderation effect

The main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies of biometrics and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

Dimension	Likert scale measurement items for the variables
Biometrics identification (BM):	*Items:* • BM1: The use of biometrics save time • BM2: The use of biometrics make it easy to do banking • BM3: Biometrics is easily accessible for transactions • BM4: Biometrics meet my transaction needs • BM5: The use of biometrics is safer • BM6: Biometrics is readily available for use for transactions • BM7: The use of biometrics is cheaper • BM8: Biometrics is more authentic • BM9: Biometrics is more convenient • BM10: Biometrics is more reliable • BM11: Biometrics keep transactions private *Literature sources:* Appaya and Varghese (2019) and Manisha *et al.* (2018)
Mobile money (MM):	*Items:* • MM1: I always use mobile money in my business • MM2: I save time when I use mobile to do my business • MM3: Mobile money is readily available when I need it • MM4: Mobile money speeds my business transactions • MM5: I save most of my money on my phone • MM6: I use mobile money to pay my suppliers • MM7: Some customers pay me using mobile money • MM8: I use mobile money more than bank • MM9: Mobile money meets my expectations • MM10: Mobile money meets my financial needs • MM11: Mobile money is safer than carrying cash • MM12: Mobile money is cheap • MM13: Mobile money is always reliable • MM14: Mobile money is easily accessible *Literature sources:* Okello Candiya Bongomin *et al.* (2020), Suri and Jack (2016), Munyegera and Matsumoto (2018), Aker *et al.* (2016)
Digital literacy (DL):	*Items:* • DL1: I have skills on operating mobile money • DL2: I have knowledge about mobile money • DL3: I can easily switch between the mobile money menus • DL4: I can easily operate the mobile money transactions • DL5: I am capable of making transactions using mobile money • DL6: I have the ability to use mobile money • DL7: I can clearly interpret the mobile money menu • DL8: I have knowledge of the mobile money apps • DL9: I can effectively use my phone to carry out mobile money transactions • DL10: I am familiar with the mobile money transactions • DL11: I am aware of all the services transacted using mobile money • DL12: I am aware about mobile money products • DL13: I can easily make payments using mobile money • DL14: I can easily borrow money using mobile money • DL15: I can easily save money on my mobile money account • DL16: The mobile money platform has helped me to save money regularly • DL17: I have reduced on my spending because of mobile money • DL18: I can easily interpret the mobile money messages • DL19: I am familiar with the mobile money PIN Literature sources: Kass-Hanna *et al.* (2022), Morgan *et al.* (2019), Chetty *et al.* (2017)

Table 1.
Summary of literature review and measurement items for the variables

(*continued*)

Dimension	Likert scale measurement items for the variables
Digital financial inclusion (DFI):	*Items:* • DFI1: I can easily access financial services because there are many digital providers near my business • DFI2: I can easily access financial services because of wide coverage by the digital providers • DFI3: I can easily access financial services from the digital providers because of its availability • DFI4: I can easily access financial services because the digital providers offer it regularly • DFI5: The financial services offered by providers are affordable • DFI6: The financial services offered by digital providers are readily available • DFI7: The digital financial services' providers offer varieties of products • DFI8: The financial services offered by digital providers suit my needs • DFI9: The financial services offered by digital providers is safe • DFI10: The financial services offered by digital providers satisfy my needs • DFI11: The financial services offered by digital providers is reliable • DFI12: The financial services offered by digital providers is convenient • DFI13: The financial services offered by digital providers is relevant • DFI14: The financial services offered by digital providers is useful • DFI15: The term and condition of use of financial services offered by digital providers is favorable • DFI16: The financial services offered by digital providers has improved my business *Literature sources:* Okello Candiya Bongomin and Munene (2019), Okello Candiya Bongomin *et al.* (2016), Demirgüç-Kunt *et al.* (2018), Alliance for Financial Inclusion (2018), Čihák *et al.* (2012)

Source(s): Authors' own creation/work

Table 1.

Little *et al.* (2007a, b) suggest that structural equation modeling (SEM) can be used to test for interaction effect of a moderator between the independent variable and dependent variable. SEM is a better method because of its superiority in combining the manifest constructs with their particular latent variables into one single model to explain a phenomenon (Hair *et al.*, 2022). Besides, SEM has ability to address the presence of measurement error within a statistical model (Hair *et al.*, 2022; Cole and Preacher, 2014). Indeed, SEM can be used to model interactions, nonlinearities, correlated independents, measurement error, correlated error terms, and multiple latent independent variables constituting multiple indicators.

According to Byrne (2010), SEM allows researchers to test for relationships between the exogenous variable, moderator, and endogenous variable through multivariate analysis techniques by constructing measurement equation and structural equation. The measurement equation is constructed to test the accuracy of proposed measurements by assessing relationships between the latent variables and their respective indicators. The structural equation is constructed to assess inter-relationships between the different variables in the model based on the study hypotheses.

Thus, in order to proceed with the test for moderation, Baron and Kenny (1986) set four conditions that should be met for moderation effect to exist in a SEM model. First, the independent and dependent variables should be associated. Second, the independent variable and moderator variable should be associated. Third, the moderator and dependent variable should have some kind of association. Finally, a relationship should exist between the independent variable, moderator, and dependent variable. These relationships are

established by running correlation analysis between the independent variable, moderator, and dependent variable (Cohen and Cohen, 1983; Aiken and West, 1991).

Hair *et al.* (2016) suggest that the measurement models for the different variables should be derived to determine the relationship between the manifest variables and their latent constructs. The measurement model is constructed to determine how well the observed variables are linked to their underlying latent constructs grounded on a sound theoretical foundation through confirmatory factor analysis (CFA). The CFA is constructed in AMOS to determine convergent and discriminant validity between the manifest variables and the latent factors (Arbuckle, 2009; Anderson and Gerbing, 1988).

Accordingly, a structural equation model combining the independent variable, moderator, dependent variable, and interaction term of the moderation was constructed through analysis of moment structures (AMOS) with bootstrap bias-corrected confidence intervals through CB-SEM. This approach was used to confirm or reject systematic relationships between multiple variables based on theories by determining how well a proposed theoretical model estimates the covariance matrix for a sample data set (Hair *et al.*, 2022; Arbuckle, 2003).

The Goodness-of-Fit (GoF) indices were used to evaluate the measurement and structural equation models. Hair *et al.* (2014) and Schreiber *et al.* (2006) recommend that the absolute values and goodness-fit-indices of Chi-square (CMIN-minimum value/DF-degree of freedom), Tucker–Lewis Index (TLI), Comparative Fit Index (CFI), Incremental Fit Index (IFI) and Root Mean Square Error of Approximation (RMSEA) with their respective cut-off points, can be used to explain how well the observed variables are linked to their underlying latent constructs.

Hair *et al.* (2010) argue that for test of interaction effect, the moderated model should have better fit indices than the non-moderated model with no interaction effect of the moderator. The cut-off point for CFI was set at $\geq$0.90 while TLI was set at $\geq$0.95, and IFI was set at $\geq$0.95. The cut-off point for RMSEA was set at $\leq$0.08 as recommended by Hair *et al.* (2014), Schreiber *et al.* (2006). The results of the CFA measurement models for the different variables and structural model are indicated in the next section.

4. Research findings

4.1 Response rate

The findings from this study indicated that data were collected from 330 respondents out of 399 samples that were selected for this study. This accounted for 83% response rate. This response rate was good enough to generate results to provide support for the hypotheses set under this study.

4.2 Demographic characteristics of samples

The findings from this study indicated that most of the respondents were female (64%) as compared to the male who comprised 36% of the respondents. Additionally, the findings showed that majority (36%) of the respondents were in the 26–33 age bracket while those in the 34–41, 18–25, 42–49, and 50+ age bracket constituted 29%, 15%, 13%, and 7%, respectively. Besides, the findings revealed that about 46% of the respondents had attained secondary level of education followed by primary level (21%), diploma (17%), bachelor degree (12%), postgraduate (1%), and no school (3%). Furthermore, the findings also indicated that majority (53%) of the businesses were formal establishments although about 47% did not have any formal kind of registration. In the same vein, the findings also showed that majority of the respondents (61%) did not own any form of permanent assets while 39% owned permanent assets that could be used as physical collateral. More so, the

findings also revealed that majority of the businesses were small firms (46%) as compared to those that were micro firms (37%) and medium firms (17%). Similarly, the findings indicated that majority of the businesses (44%) had been in operation for at least 5 years and less whereas those that had been in operation for 6–10 years, 11–15 years, and 15 years and above comprised 36%, 14%, and 6%, respectively. The findings also showed that majority of the business owners/managers had not acquired any sort of business skills (52%) and about 48% had acquired some sort of business skills through business training. The findings also indicated that majority of the MSMEs deal in general merchandise (30%) followed by restaurants (28%), garments and clothes (15%), other products (14%), and farm produce (12%). In addition, the findings also showed that majority of the businesses cited lack of capital (39%) as the number one factor affecting business operation followed by low sales (32%), lack of financial skills (10%), limited access to finance (9%), absence of collateral (5%), and other factors (5%). The findings from this study further revealed that about 72% of the businesses kept business records while 28% did not keep business records. The findings also noted that most businesses (40%) used Self-Help Groups due to convenience as their main source of capital and finance as compared to VSLAs (31%), microfinance (18%), banks (4%), and SACCOs (7%). The results are presented in Table 2.

4.3 Descriptive statistics

Descriptive statistics were generated for each of the variable under this study. The findings indicated the following mean scores and standard deviation for the different variables: Biometrics identification (mean = 3.1935; S.D = 0.83033); mobile money (mean = 3.9231; S.D = 0.62232); digital literacy (mean = 4.1990; S.D = 0.59791); digital financial inclusion (mean = 3.4754; S.D = 1.04113). The distance between the mean from the standard deviation indicated that our observed data fitted well to the theoretical model (Field, 2005).

4.4 Pearson's correlation analysis

The main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies of biometrics and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. Pearson's correlation analysis was performed to establish the relationship between the variables under this study. The results are indicated in Table 3 and discussed below based on Cohen (1992).

The Pearson's correlation analysis revealed that biometrics identification and digital financial inclusion are significantly and positively related ($r = 0.367$; $p < 0.01$). This means that increase in use of biometrics identification results into increase in digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda but through a moderate relationship.

In addition, the Pearson's correlation analysis also showed that there is a significant and positive relationship between mobile money and digital financial inclusion ($r = 0.113$; $p < 0.05$). This implies that increase in mobile money use can increase digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda but through a weak relationship.

Similarly, the Pearson's correlation analysis indicated that there is a significant and positive relationship between digital literacy and digital financial inclusion ($r = 0.202$; $p < 0.05$). This implies that increase in digital literacy results into increase in digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda but through a weak relationship.

Furthermore, the Pearson's correlation analysis also revealed that digital literacy and biometrics identification are significantly and positively associated ($r = 0.115$; $p < 0.05$). This

Characteristics		Frequency (n = 330)	Percentage (%)
Gender:	*Male*	211	64
	Female	119	36
Age:	*18–25*	49	15
	26–33	119	36
	34–41	96	29
	42–49	43	13
	50+	23	7
Education level:	*No school*	10	3
	Primary certificate	69	21
	Secondary certificate	152	46
	Diploma	56	17
	Bachelor degree	40	12
	Postgraduate degree	3	1
Business registration:	*Yes*	175	53
	No	155	47
Asset ownership:	*Yes*	129	39
	No	201	61
Business categorization:	*Micro scale*	122	37
	Small scale	152	46
	Medium scale	56	17
Years in operation:	*5 years or less*	145	44
	6–10 years	119	36
	11–15 years	46	14
	More than 15 years	20	6
Business skills training:	*Yes*	158	48
	No	172	52
Products sold:	*General merchandise*	99	30
	Farm produce	40	12
	Garments and clothes	49	15
	Food	96	28
	Other products	46	14
Challenge in business:	*Lack of capital*	129	39
	Limited access to finance	29	9
	Lack of financial skills	33	10
	Absence of collateral	16	5
	Low sales	107	32
	Other factors	16	5
Business record keeping:	*Yes*	238	72
	No	92	28
Source of capital:	*Bank*	14	4
	Microfinance	59	18
	SACCOs	23	7
	VSLAs	102	31
	Self-Help Groups	132	40

Source(s): Authors' own creation/work

Table 2. Demographic characteristics

means that increase in digital literacy leads to increase in use of biometrics identification among the unbanked poor women, youth and PWDs in rural Uganda but through a weak relationship.

Finally, the Pearson's correlation analysis showed that there is a significant and positive relationship between digital literacy and mobile money ($r = 0.329$; $p < 0.01$). This implies that increase in digital literacy leads to increase in mobile money use among the unbanked poor women, youth and PWDs in rural Uganda but through a moderate relationship.

4.5 Measurement models

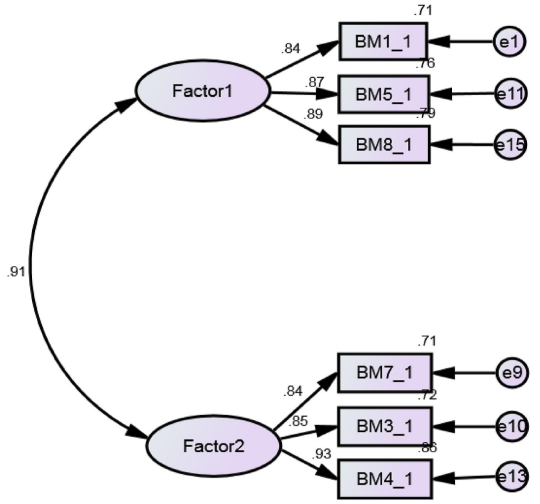
Confirmatory factor analysis was performed in AMOS to establish convergent and discriminant validity between the manifest variables and their particular latent constructs under this study. The results indicated that all the variables attained better model fit indices based on the recommended GoF used in this study. The CFA results are indicated in Figures 2–5.

The results showed that the standardized parameter estimates of the initial measurement model were all significant ($p < 0.001$) for biometrics identification with Chi-square (x^2) of 25.253 and degrees of freedom of 8, Incremental Fit Index (IFI) of 0.992 above the recommended 0.95, and Tucker Lewis Index (TLI) of 0.985 above the recommended 0.95. The Comparative Fit Index (CFI) was 0.992 above the recommended 0.90, and the Root Mean Square Error of Approximation (RMSEA) was 0.071 below the recommended cut-off point of ≤0.08. The CFA results showed that three items of BM1, BM5, and BM8 loaded on factor 1 while three other items of BM7, BM3, and BM4 loaded on factor 2 of biometrics identification. Overall, five items were dropped and six items were retained during CFA process as indicated in Figure 2.

Variables	N	Mean	Std. Dev	(1)	(2)	(3)	(4)
Biometrics identification (1)	330	3.1935	0.83033	1			
Mobile money (2)	330	3.9231	0.62232	0.244**	1		
Digital literacy (3)	330	4.1990	0.59791	0.115*	0.329**	1	
Dig financial inclusion (4)	330	3.4754	1.04113	0.367**	0.113*	0.202*	1

Note(s): **. Correlation significant at the 0.01 level (two-tailed)
*. Correlation significant at 0.05 level (two-tailed)
Legends: Dig financial inclusion – digital financial inclusion
Source(s): Authors' own creation/work

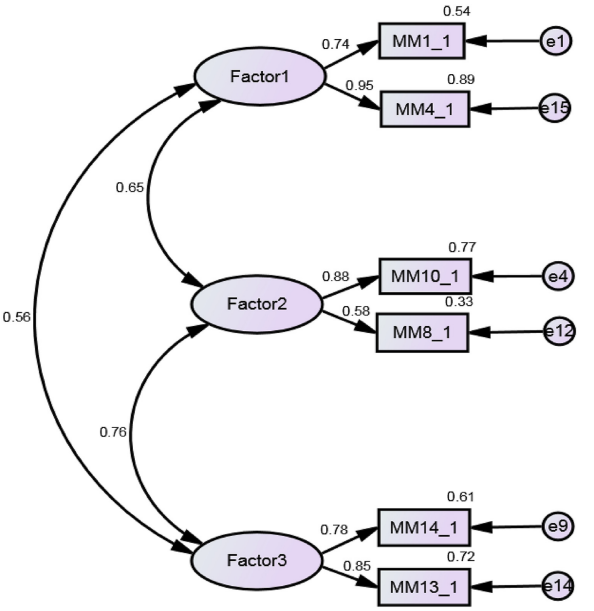
Table 3.
Pearson's correlation analysis



Chi-square = 25.253; Degrees of freedom (Df) = 8
;Incremental Fit Index (IFI) = .992; Tucker Lewis Index (TLI) = .985
Comparative Fit Index (CFI) = .992; Root Mean Square Error of Approximation (RMSEA) = .071

Source(s): Author(s) own creation/work

Figure 2.
CFA measurement model for biometrics identification



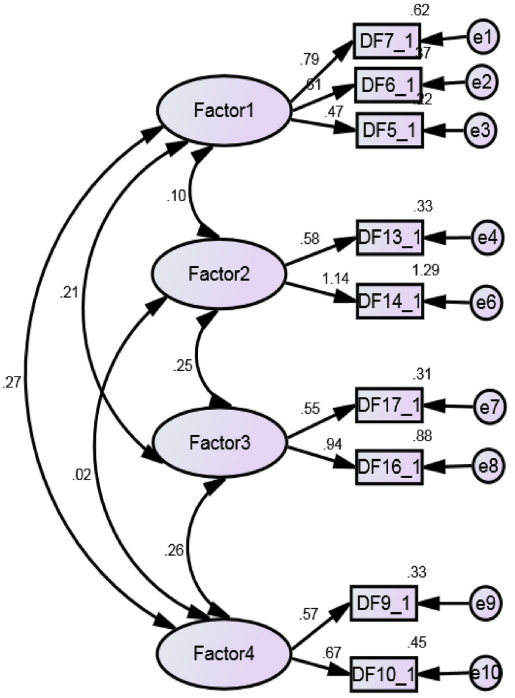
Chi-square = 21.113; Degrees of freedom (Df) = 6
;Incremental Fit Index (IFI) = 0.985; Tucker Lewis Index (TLI) = 0.963
Comparative Fit Index (CFI) = 0.985; Root Mean Square Error of Approximation (RMSEA) = 0.077

Source(s): Author(s) own creation/work

Figure 3.
CFA measurement model for mobile money

Additionally, the results revealed that the standardized parameter estimates of the initial measurement model were all significant ($p < 0.001$) for mobile money with Chi-square (x^2) of 21.113 and degrees of freedom of 6, and Incremental Fit Index (IFI) of 0.985 above the recommended 0.95, and Tucker Lewis Index (TLI) of 0.963 above the recommended 0.95. The Comparative Fit Index (CFI) was 0.985 above the recommended 0.90, and the Root Mean Square Error of Approximation (RMSEA) was 0.077 below the recommended cut-off point of ≤0.08. The CFA results revealed that two items of MM1 and MM4 loaded on factor 1, two other items of MM10 and MM8 loaded on factor 2, and two other items of MM14 and MM13 loaded on factor 3 of mobile money. Overall, eight items were dropped and six items were retained during CFA process as indicated in Figure 3. This is based on the Item Response Theory (IRT), which states that the fewer the items, the better the measures of a variable that is more superior to the Classical Test Theory (CTT) that rely on many items (Embretson and Reise, 2000).

More so, the results also indicated that the standardized parameter estimates of the initial measurement model were all significant ($p < 0.001$) for digital literacy with Chi-square (x^2) of 33.809 and degrees of freedom of 21, Incremental Fit Index (IFI) of 0.978 above the recommended 0.95, and Tucker Lewis Index (TLI) of 0.961 above the recommended 0.95. The Comparative Fit Index (CFI) was 0.977 above the recommended 0.90, and the Root Mean Square Error of Approximation (RMSEA) was 0.042 below the recommended cut-off point of ≤0.08. The CFA results indicated that three items of DF7, DF6, and DF5 loaded on factor 1, two other items of DF13 and DF14 loaded on factor 2, and two other items of DF17 and DF16 loaded on factor 3 while two other items of DF9 and DF10 loaded on factor 4 of digital literacy. Overall, ten items were dropped and nine items were retained during CFA process as indicated in Figure 4. This is based on the Item Response Theory (IRT), which states that the



Chi-square = 33.809; Degrees of Freedom (Df) = 21
;Incremental Fit Index (IFI) = .978; Tucker Lewis Index (TLI) = .961
Comparative Fit Index (CFI) = .977; Root Mean Square Error of Approximation (RMSEA) = .042

Source(s): Author(s) own creation/work

Figure 4.
CFA measurement model for digital literacy

fewer the items, the better the measures of a variable that is more superior to the Classical Test Theory (CTT) that rely on many items (Embretson and Reise, 2000).

Finally, the results further revealed that the standardized parameter estimates of the initial measurement model were all significant ($p < 0.001$) for digital financial inclusion with Chi-square (x^2) of 62.999 and degrees of freedom of 24, Incremental Fit Index (IFI) of 0.991 above the recommended 0.95, and Tucker Lewis Index (TLI) of 0.986 above the recommended 0.95. The Comparative Fit Index (CFI) was 0.991 above the recommended 0.90, and the Root Mean Square Error of Approximation (RMSEA) was 0.062 below the recommended cut-off point of ≤0.08. The CFA results indicated that four items of FI3, FI5, FI6, and FI7 loaded on factor 1, three other items of FI14, FI11, and FI9 loaded on factor 2, and two other items of FI8 and FI10 loaded on factor 3 of financial inclusion. Overall, seven items were dropped and nine items were retained during CFA process as indicated in Figure 5.

4.6 Moderation effect analysis in AMOS

The main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies of biometrics identification and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

The structural equation model was built in AMOS through bootstrap to test for the moderation hypothesis. Two models were constructed: Model 1 had direct effect of biometrics

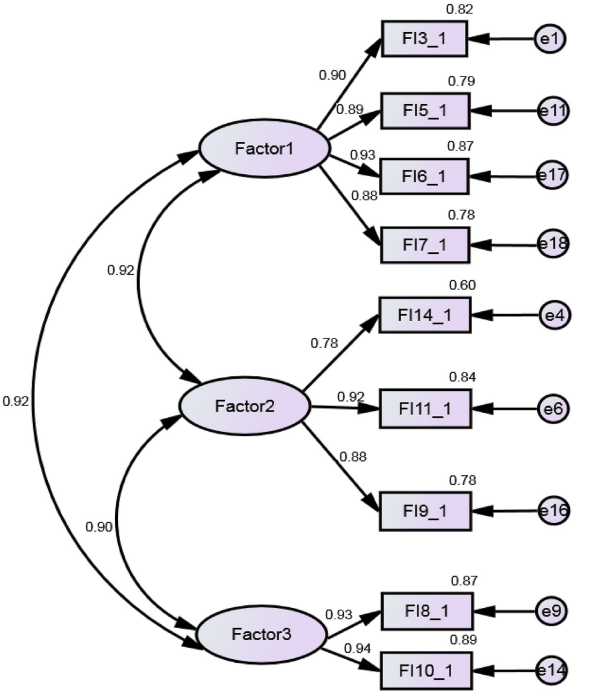


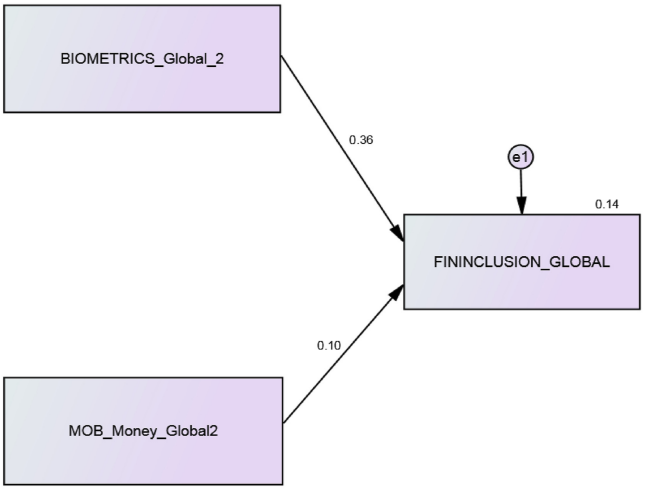
Figure 5.
CFA measurement model for digital financial inclusion

Source(s): Author(s) own creation/work

identification and mobile money on digital financial inclusion. Model 2 had direct effect of biometrics identification and mobile money on digital financial inclusion with indirect effect of digital literacy (see Figures 6 and 7).

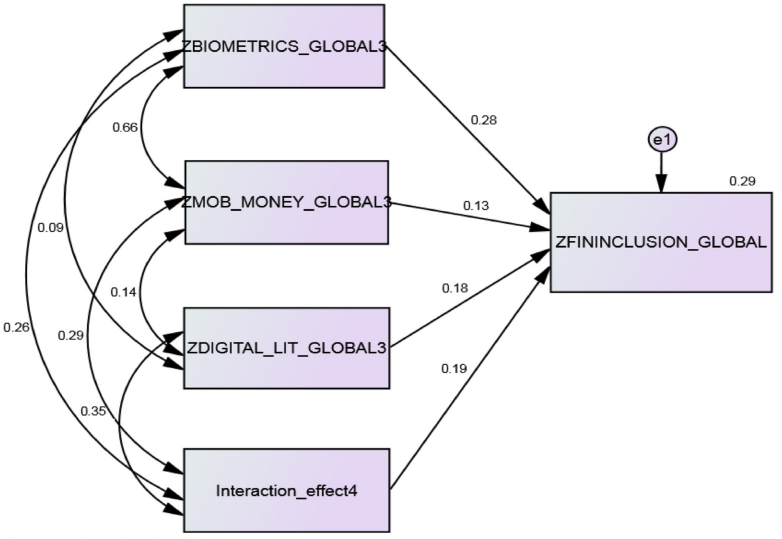
The results indicated that Model 2 had excellent model fit indices as compared to Model 1 with Chi-square (x^2) of 0.801 and degrees of freedom of 1, Incremental Fit Index (IFI) of 1.003 above the recommended 0.95, and Tucker Lewis Index (TLI) of 1.009 above the recommended 0.95. The Comparative Fit Index (CFI) was 1.000 above the recommended 0.90, Normed Fit Index (NFI) was 0.988, and the Root Mean Square Error of Approximation (RMSEA) was 0.000 below the recommended cut-off point of ≤0.08. The results are indicated in Table 4.

The structural equation model results further showed that digital literacy has a significant and positive moderating effect in the relationship between financial technologies (biometrics identification and mobile money) and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda ($\beta = 0.192$; $t = 4.127$; $p < 0.001$). The introduction of interaction effect of digital literacy increases the impact of financial technologies (biometrics identification and mobile money) on digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda by 15%. This confirms hypothesis *H3* of this study. Overall, a combination of financial technologies of biometrics identification and mobile money together with digital literacy explain 29% variation in digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. This is



Source(s): Author(s) own creation/work

Figure 6. Non-moderated structural equation model in AMOS



Source(s): Author(s) own creation/work

Figure 7. Moderated structural equation model for interaction effect of digital literacy in AMOS

indicated in the moderated structural equation model in Figure 7 and ModGraph for interaction effect in Figure 8.

In addition, the results also indicated that biometrics identification significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda ($\beta = 0.312$; $t = 5.156$; $p < 0.001$). This supports hypothesis *H1a* of this study.

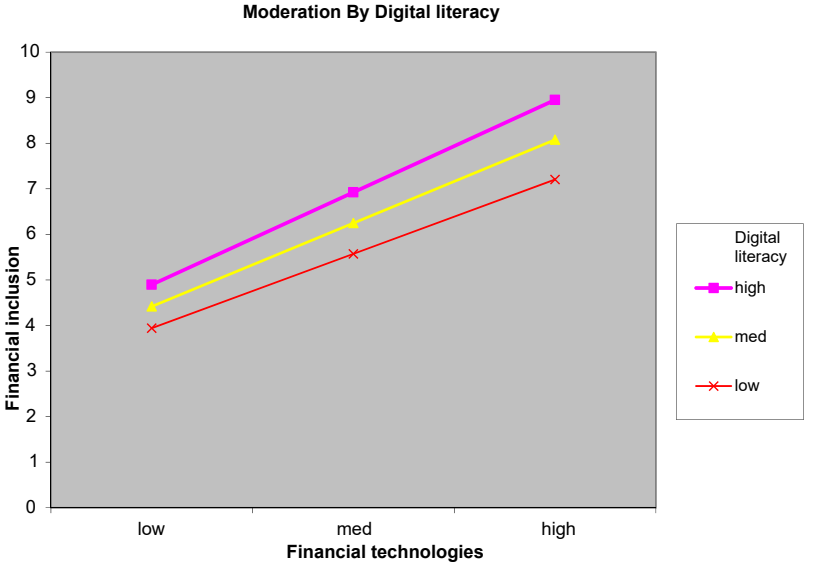
Besides, the results showed that mobile money significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda ($\beta = 0.141$; $t = 2.311$; $p < 0.01$). This corroborates with hypothesis *H1b* of this study.

Hypotheses	Path coefficients	SE	*t*-value	*p*-value
Biometrics ID → Dig financial inclusion	0.312	0.061	5.156	***
Mobile money → Dig financial inclusion	0.141	0.061	2.311	0.021
Digital literacy → Dig financial inclusion	0.175	0.037	4.007	***
Digital Literacy × financial technologies → Dig financial inclusion	0.192	0.002	4.127	***

	Non-moderated model (1)	Moderated model (2)
Chi-square/CMIN	3.259	0.801
Degrees of freedom (Df)	10	1
Probability (P)	0.102	0.371
Incremental fit index (IFI)	0.976	1.003
Tucker–Lewis index (TLI)	0.966	1.009
Comparative fit index (CFI)	0.989	1.000
Normed fit index (NFI)	0.960	0.988
Root mean square error of approximation (RMSEA)	0.078	0.000

Note(s): $n = 330$; significance level: ***$p < 0.001$; **$p < 0.01$
Legends: Biometrics ID-biometrics identification; Dig financial inclusion – digital financial inclusion
Source(s): Authors' own creation/work

Table 4.
Structural equation model for moderation effect



Source(s): Author(s) own creation/work

Figure 8.
ModGraph for interaction effect of digital literacy

The results also indicated that digital literacy significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in Uganda ($\beta = 0.175$; $t = 4.007$; $p < 0.001$). This lends support to hypothesis *H2* of this study. The results of the hypotheses testing through structural equation modeling with bootstrap in AMOS are indicated in Table 4.

5. Discussion of results

The main purpose of this study is to test for the interaction effect of digital literacy in the relationship between financial technologies of biometrics and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda.

5.1 Digital literacy: moderator between financial technologies and digital financial inclusion

The results from this study indicated that digital literacy has a significant and positive moderating effect in the relationship between financial technologies (biometrics identification and mobile money) and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. This result is supported by Saini (2019) who argues that digital literacy can help the poor like the unbanked women, youth and PWDs in developing countries to analyze digital credit provided by FinTech in order to make better choice to avoid the problem of over borrowing, excessively high interest rates, and over-indebtedness. Digital literacy can allow them to understand the terms and conditions stated on digital contracts before signing to avoid risky implications during consumption.

Additionally, Prete (2022) indicates that digital literacy can allow individuals like the unbanked poor women, youth and PWDs to acquire skills needed to become digitally proficient to use digital technology, communication tools, and networks to obtain and evaluate information, communicate with others, and perform digital transactions in technology-rich environment. Digital literacy helps vulnerable individuals such as the unbanked poor women, youth and PWDs in developing countries to compare different financial products available on the market before consuming them to ensure that they suit their needs in terms of cost and reliability. This enables them to select and consume suitable digital financial products, which results into increased financial inclusion.

Furthermore, Abdulquadri *et al.* (2021) also suggest that digital literacy can help individuals like the unbanked poor women, youth and PWDs to acquire skills to effectively communicate through innovative channels such as chatbots to ask questions, make verifications, and privately provide personal information through proper engagement on digital financial issues in order to satisfy their financial needs.

This finding corroborates with Kass-Hanna *et al.* (2022) who found that increase in financial and digital literacy levels was associated with increase in savings, borrowings, and risk management among poor women living in rural areas in seven South Asian and Sub-Saharan African countries, especially for those dealing with Non-Bank Financial Institutions or mobile money service providers.

Digital literacy linked to acquisition of skills and knowledge to enhance digital proficiency of individuals such as the unbanked poor women, youth and PWDs can be acquired through social interaction grounded in the Social Learning Theory by Bandura (1986). The unbanked poor women, youth and PWDs can acquire digital skills and knowledge through observation, imitation and modeling in social interaction. Social Learning Theory that promote interplay between cognitive, affective, biological and socio structural aspects in the process of learning, can help the unbanked poor women, youth and PWDs to acquire the expected digital knowledge and skills to efficiently use financial technologies like biometrics and mobile money to access and use financial services in daily life (Ramsden, 1992).

Conclusively, digital literacy can help the unbanked poor women, youth and PWDs in developing countries like Uganda to understand the risks that they may suffer when using digital financial services. It can provide them with abilities to evaluate fraud and cyber security risks such as phishing, pharming, spyware, and SIM card swaps linked to use of digital financial products (Banco de Portugal, 2018). This result supports our hypothesis (H3) set under this study.

5.2 Biometrics identification and digital financial inclusion

The results from this study also revealed that biometrics identification significantly and positively promote digital financial inclusion among the unbanked poor women, youth and

PWDs in rural Uganda. This result is similar to Marron (2013) who discovered that use of an iris recognition system linked to automated teller machine with a specialized iris camera helped more than a third of the unprecedented 630,000 Syrian refugees to access monthly cash assistance through Cairo Amman Bank.

According to the World Bank (2018a, b), use of FinTech tools like biometrics for identification purpose, can increase access to and use of financial services among the vulnerable poor by easing identification requirement.

Duflo and Udry (2004) also observe that digital identification technology can be instrumental in ensuring access to financial services in order to empower vulnerable poor individuals. Biometrics can potentially lead to more adoption of digital financial services, especially by the unbanked poor who do not have formal identity documents. Biometrics make it easier for the unbanked and underserved population like the unbanked poor women, youth and PWDs in developing countries like Uganda to open a transaction account, enable more cost-effective and remote customer on-boarding, and facilitate the delivery of additional financial services (Bank for International Settlements, 2016).

Correspondingly, the World Bank Identification for Development Initiative (2018) concurs that biometrics identification system rapidly registers, prevents duplication, and verifies the identities of individuals whether they have an identification document or not. This helps to solve the challenge of lack of identification while accessing and using financial services to avoid fraud. Biometrics identification can enhance the security credentials and potentially makes it a more secure process to enable financial inclusion among the unbanked poor women, youth and PWDs in developing countries like Uganda. This result corresponds to our hypothesis (H1a) of this study.

5.3 Mobile money and digital financial inclusion

The results from this study also showed that mobile money significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. The authenticity of this result is linked to the fact that mobile money products like M-Shwari consumer loans offered by Commercial Bank of Africa to M-PESA customers has been instrumental in providing digital credit in Kenya.

Okello Candiya Bongomin *et al.* (2022) contend that mobile money can leverage cost and geographical barriers in terms of distance, which results into increased financial inclusion of the unbanked poor women, youth and PWDs in developing countries like Uganda.

Besides, Kamande *et al.* (2021) state that mobile money can provide transaction records that can be used by the unbanked poor individuals when applying for loans since they have limited collateral and cannot convincingly prove repayment capacity because of the problem of information asymmetry.

In the same vein, Shaikh *et al.* (2023), Wang and He (2020) also argue that mobile money can accommodate and allow the unbanked poor women, youth and PWDs to transact affordably in tiny amounts whenever they wish, subject to the vagaries of unpredictable or unreliable connections and other risks. This is because it is more suitable for the unbanked poor who have very small and unpredictable cash flows.

Hussein (2020) further observes that mobile phones enable customers to make or receive payments, transfer money less expensively, and safely store value electronically with a bank or non-bank permitted to store electronic value. This can reduce the risk of loss, theft, and other financial crimes related to cash transactions.

Mobile money has the potential to provide the most reliable digital channel to expand affordable, effective, and safe financial services because of the ever increasing level of mobile telephony network coverage, fast growing phone subscriptions, and Smartphone ownership in rural areas in developing countries. This result renders support to our hypothesis (H1b) of this study.

5.4 Digital literacy and digital financial inclusion

Finally, the results indicated that digital literacy significantly and positively promote digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. This result is supported by Medhi *et al.* (2009) who found that low levels of numerical literacy, unavailability of options in local languages, lack of familiarity with banking jargon, and application complexity made mobile money users in India, Kenya, Philippines, and South Africa to rely on agents to fulfill their transactions.

The OECD (2020) observes that digital literacy can help the financially excluded and underserved poor population who are susceptible to risk and frauds to be prepared to make the right decisions before consuming digital financial products. Digital literacy enables the poor like the unbanked women, youth and PWDs to acquire skills that they can use to fully take advantage of the opportunities and minimize the risks brought by FinTech.

More so, Yoshino *et al.* (2020) also assert that digital literacy can help the unbanked poor women, youth and PWDs to analyze simple instructions on the functioning of digital financial products and plain indications on where to obtain more information and how to get recourse on mistakes made over the FinTech platforms. This can ensure safe digital financial environment, which can lead to more uptake and use of digital financial services, hence, increased digital financial inclusion.

Relatedly, digital literacy can reduce digital divide among the educated and illiterate consumers of digital financial services. This can result into increased access and use of digital financial services by the unbanked and underserved individuals from all section of the population (OECD, 2020). Digital literacy can give the poor sophistication to process financial information before consuming digital financial products, which can result into continued use of digital financial services in developing countries like Uganda.

6. Conclusion

The results from this study revealed that digital literacy has a significant and positive moderating effect in the relationship between financial technologies of biometrics identification and mobile money and digital financial inclusion among the unbanked poor women, youth and PWDs in rural Uganda. FinTech can expand access to financial services to the unbanked and underserved population to access varieties of financial services at an affordable cost than that provided by the traditional banks.

The results from this study also showed that biometrics identification significantly and positively promote digital financial inclusion among the unbanked women, youth and PWDs in rural Uganda. Biometrics identification can provide reliable form of identification for the unbanked individuals who lack identification documents so as to access financial services from banks.

Furthermore, the results from this study also indicated that mobile money significantly and positively promote digital financial inclusion among the unbanked women, youth and PWDs in rural Uganda. Mobile money can reduce the risk of loss, theft and other financial crimes related to cash transactions, and as well lower costs associated with cash transactions.

Lastly, the results showed that digital literacy significantly and positively promote digital financial inclusion among the unbanked women, youth and PWDs in rural Uganda. Digital literacy can help the unbanked and underserved population to gain skills and capabilities that they can adequately use to assess potential risks and implications of consuming certain digital financial products offered by digital financial services' providers.

7. Implications and outlook

The results from this study can be helpful in the following ways:

First, the government of Uganda should support the unbanked poor women, youth, PWDs and other equally vulnerable groups, especially in the rural communities to understand and use FinTech. This can be achieved through digital literacy that can help them to embrace digital financial services and competently navigate and perform digital transactions over digital innovation platforms like the mobile money without making errors.

Second, the government of Uganda can use this finding to advocate for the design of appropriate digital infrastructure to reach remote areas and ensure "last mile connectivity for digital financial services' users." The use of off-line solutions can complement the absence or loss of on-line network connectivity for biometrics and mobile money. This can scale-up access to and use of financial services, especially among the unbanked rural population.

Third, the findings from this study can be used by mobile money providers in Uganda to extend mobile money services to reach the unbanked vulnerable population in rural areas. The mobile money providers can use this study to identify areas with limited mobile money network coverage and mobile money agents. As a result, they can increase mobile money network coverage and number of mobile money agents to promote financial inclusion.

Fourth, the findings from this study can be used to evaluate digital literacy needs among the vulnerable groups and other section of the population in Uganda. This can help the government of Uganda to develop and design curriculum to train the digitally illiterate population to enhance national digital capabilities to achieve increased adoption and use of mobile money to spur financial inclusion.

Fifth, the findings from this study can be used by banks to adopt and use biometrics to provide identification, especially for the vulnerable and illiterate individuals in rural areas in Uganda to solve the problem of lack of identification and documentation requirements. Biometric machines can be installed at rural bank branches and mobile money agents' point-of-sales. This can relief the unbanked rural population from formal identification requirements that can increase access to and use of digital financial services.

Sixth, the government of Uganda should consider combining digital literacy with financial literacy and include it in the national school curriculum. Conducting digital and financial literacy in schools can impart digital skills and financial knowledge among younger adults to become familiar with financial technologies and digital money matters as they grow. Consequently, this will help them to competently use digital financial services, hence, increased scope of financial inclusion.

Seventh, this study integrates the role of Social Learning Theory in explaining acquisition of digital skills and knowledge by women, youth and PWDs to access and use financial services through financial technologies like biometrics and mobile money. A blend of Social Learning Theory and Financial technologies can offer a better strategy to increase financial inclusion among vulnerable groups like women, youth and PWDs in the unbanked rural areas in a developing country like Uganda.

Eighth, the findings from this study can be replicated in other developing countries to promote the adoption of financial technologies such as biometrics and mobile money to increase access to and use of financial services in the presence of digital literacy since this has revealed significant and positive effect in Uganda. The adoption and use of digital financial services can result into increased financial inclusion of the unbanked population, especially in other developing countries in sub-Saharan where there is high phone ownership with high numbers of mobile money agents.

Last, this paper shades more light on the importance of conducting digital literacy in the ever complex and dynamic global financial technology ecosystem in the presence of rampant cyber risks. Digital literacy can help the unbanked and underserved poor women, youth and PWDs in developing countries who use financial technologies to acquire digital skills to participate competently within the digital financial market. This can be achieved by

delivering digital literacy trainings by providers to reduce the persistent occurrence of frauds within the digital financial ecosystem.

8. Research limitations and further studies

The data for this study were collected mainly from poor women, youth and PWDs. Further studies may look at data collected from other sections of the vulnerable population in Uganda and other developing countries.

Additionally, the data for this study were collected only from Uganda as a developing country. Thus, additional data may be obtained from other developing countries to draw conclusive and generalized empirical evidence.

Besides, the current study used cross sectional design to collect the data. Therefore, future studies may adopt longitudinal research design to investigate the impact of financial technologies on digital financial inclusion in the presence of digital literacy across different time range.

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