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The Influence of Digital and Financial Literacy on Interest-Free Banking Financial Inclusions: Insight from Ethiopia's Country-Specific Socioeconomic Survey 2018–19

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Abstract

This study aimed to investigate the influence of financial and digital literacy on the use of interest-free banking services as a policy tool for financial inclusion in Ethiopia. The study used Ethiopia's country-specific Socioeconomic Survey (ESS) 2018–19 data, which included clustered dataset structures such as regional, place, household, and individual differences. Descriptive statistics were used to demonstrate variation in digital financial literacy, financial literacy, and Interest Fee Banking (IFB) service use among adults in the country. Mixed-effects Econometric modeling was estimated by applying within-household random variance-controlled maximum likelihood techniques in STATA algorithms. These methods aim to estimate the fixed effects and random variations in IFB use among adults efficiently while capturing cluster-specific deviations. These modeling and estimation techniques provide a powerful and flexible approach to ensuring robustness and trustworthy findings in survey data contexts. The findings show that adults' digital financial literacy, financial literacy, IFB service use, and other characteristics of the financial literacy mean score are distributed asymmetrically among geographical places, genders, incomes, and religious affiliations. Additionally, these data insight results demonstrate that digital and financial literacy-restricted random effects predictor parameters have a positive and significant influence on IFB usage. This implies that enhancing adults' digital and financial knowledge, attitudes, and behaviors results in a significant increase in financial inclusion in Ethiopia at Citrus Paribus. Lastly, the researchers recommend. Robust policy intervention goals should be tailored to the values and principles of the IFB model rather than implementing a uniform traditional approach to financial inclusion. The holistic strategic solution for efficient digital-financial literacy and innovative financial products and services development required to be prioritized focuses on underserved communities such as gender, unemployment, rural, geographical, religious, and other persistent barriers that have contributed to Ethiopia's involuntary financial exclusion.

Keywords: *digital financial literacy, financial literacy, financial inclusion, interest-free banking, restricted maximum likelihood, REME*

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Introduction

Prior studies on financial inclusion argue that adults need tailored financial services based on the realities of local jurisdictions, and their experiences can boost sustainable development and inclusive growth (Uddin, S., et al. (2020), Amaroh et al. (2019), Demirgüç-Kunt et al. (2013), (2015), and (2017), and Abedifar et al. (2016)). Particularly, according to the World Bank 2021, Demirgüç-Kunt et al. (2018), Trends, G. (2017), and Wang, X., & Fu, Y. (2021), technology-integrated financial services have garnered an increasing amount of interest in recent years due to being linked to at least eight of the United Nations' 17 Sustainable Development Goals. Integrating into homegrown economic reforms called Ethiopia 2030: Particularly aligned with the SDGs, Ethiopia is working on the programs of the National Financial Inclusion Strategy (NFIS) and national digital transformations. This study is motivated to contribute to these programs to achieve national financial inclusion and digital transformations.

The concept of financial inclusion (FI) encompasses all access, usage, and quality dimensions of financial services and products provided to users (Kumari, 2021). FI requires a simultaneous realization of the accessibility, usage, and benefits of financial services to promote financial well-being as well as economic and social inclusion in a society (OECD, 2013). More importantly, optimal financial inclusion, according to Ozili P.K. (2020) and the Independent Evaluation Group (2023), also includes sharia-compliant financial services, or specifically the IFB service provision process, that grants access to financial services aligned with digital technology at a price that is affordable to the poorest and most excluded communities.

In Ethiopia, financial inclusion policy reforms driven by public demand facilitated the launch of IFB Windows in 2013 by the NBE and are aimed at reducing financial exclusion. This reform process later on in 2019 enabled the creation of full-fledged IFB banks, ZamZam SC Bank, Hijra Bank SC, and others under formulation. NBE Directive SBB/72/2019 defines IFB business as "banking business that mobilizes or advances funds in a manner consistent with Islamic law or sharia principles. Nowadays, many formal financial institutions and microfinance institutions in Ethiopia offer Sharia-compliant, interest-free banking and financial services. While these products were initially developed to cater to the needs of the Muslim community for financial inclusivity, they are currently open to all individuals and businesses, regardless of religious affiliation.

However, despite the incremental progress, Ethiopia is characterized by poor financial inclusion (Pragma, 2020; ESS, 2018–2019; and World Bank Findex, 2017); 35% of the population owns a bank account, versus 83% in Kenya or 50% in Rwanda; only 0.5% of farm workers receive payments via a bank account; many SMEs obtain finance from the informal financial sectors of Equb and Edir; also, lack of adequate financial resources, distance, religious, and undocumented are important barriers to financial inclusion. The other problem is that the distribution of financial institutions is highly skewed toward urban areas. CEPHEUS reports for 2019 show that 34.4% of bank and insurance branches are in Addis Ababa, leaving the rural poor excluded from banking services. And as Berhanu et al. (2020) found, financial inclusion strategies are not as successful as in other East African countries. Their study also found that Ethiopians prefer informal savings clubs to formal financial institutions. In this style, according to Desalegn, G., and Yemataw, G. (2017), despite higher usage among rural adults, interest-free banking is less known by individuals, households, and the community.

Debebe (2015), Bekele (2018), Hailu (2015), and others have found that Ethiopian bank clients and SMEs do not make proper use of interest-free financial goods and services. Even more problematic is that the non-Muslim community believes these shariah-compliant products are only for Muslims; they doubt that this financing model is more of a promotion of Islamic religion; they suspect it will replace traditional banking; the language and Arabic terminologies are less understandable to Ethiopian customers; and there are some social and cultural complications. On the other hand, there is a persistent need for the government to implement enabling policies (Desalegn, G., and Yemataw, G. (2017)) to reduce gender, religion, and urban-rural inequalities and promote financial inclusion in Ethiopia.

Yet recent discussions have shifted to digital technologies and services. According to Brennen and Kreiss (2016), this process of change in the financial system is often referred to as ’digitalization’, which is the transition of businesses through the use of digital technologies, products, and services. Specifically, the digital age demands digital financial inclusion," which refers to the use of digital technologies to expand access to financial services for underserved populations (Golden and Cordie (2022), Morgan et al. (2019), and the Toronto Centre (2019). They also argue that this concept is closely related to financial literacy, which is the ability to understand and manage financial products and services effectively. According to the World Bank (2018b), one of the main

obstacles to adult financial inclusion is a lack of financial literacy. In the same vein, Ethiopia faces challenges in accessing formal financial services due to poor financial and digital literacy, cash usage, and unbanking, as indicated by Kim, N. (2018.).

The "Digital Ethiopia for All" policy recognizes that the lack of adequate digital skills limits the adoption of digital initiatives across various sectors, hindering communities from accessing financial services and other opportunities. In this context, to promote digitization integrated with an inclusive financial system, What is the influence of digital and financial literacy on interest-free financial service use in the context of an Ethiopian local setting? And, How do adult demographic, socioeconomic, and geographic characteristics and variations influence IFB use?

Prior research (Siddique et al., 2022; Zauro et al., 2020; El Qorchi, 2005; Ahmed, Z., 1991) shows that non-interest finance promotes economic growth and justice. According to Abedifar et al. (2015) and Iqbal & Mirakhor (2011), these institutions benefit from promoting financial inclusion by upholding the key principles of social justice, ethical and religious considerations, and resource sharing between the haves and have-nots. Others also assert that this alternative finance can create tailored financing options for rural MSMEs in agriculture, livestock, and cottage industries, and they aspire to reach underserved communities, build entrepreneurial abilities, grow their businesses, and empower women by encouraging them to participate actively in economic activities and achieve financial inclusion (Naceur et al., 2015; Ahmed, 2020; Kabeer, 2005).

Ethiopia lacks knowledge regarding how digital and FL affect adult financial inclusion and the use of interest-free banking products. Previous studies (Aman et al., 2021; Ali, A. S. (2020); Hailu, S. M., & Bushera, I. (2020); Fikadu, 2016; and a few others) have not addressed the basic research questions mentioned above. In this regard, exploring how adult digital and financial literacy influences financial inclusion via IFB services becomes imperative, with particular attention to local contexts and sub-national realities. To address these gaps, this study has two key objectives: firstly, to analyze the influence of digital and financial literacy on adult IFB financial inclusion in Ethiopia, and secondly, to investigate the effect of demographic, socioeconomic, and geographic disparity on IFB financial inclusivity.

Henceforward, policymakers, and financial service providers can use the findings of this study to progressively improve financial inclusion and the development of digital financial services in the

Sharia-compliant banking industry. Additionally, this study empirically supports capacity-building interventions in digital and financial literacy. as well as contributes interest-free banking and finance products and services, that continue to grow more popular among a wide range of diverse socioeconomic groups.

Review of Related Literature

Theoretical and Conceptual Review:

Theoretically, Shariah-compliant banks serve the same role as traditional banks but must follow Shariah rules and principles. Muslim believers Trade (halal) and transactions are governed by Allah's (SWT) Divine decree in Surah Al-Baqarah, verse 275, which defines permitted trade and prohibited interest. The most well-known Sharia regulation in Islamic financial theory is the prohibition of usury. In finance, lenders and borrowers cannot charge or pay interest, also known as riba in Arabic.

The ban has been explained in five ways: it is unfair; it corrupts society; it suggests the improper possession of other people's property; the ultimate consequence is negative; and, ultimately, it demeans and reduces human personality (Chong and Liu 2009). Shariah-compliant banking practices prohibit people from earning money on money to prevent capital owners from growing wealthy at the expense of borrowers. According to studies conducted by Aracil (2019), Musa et al. (2020), and Sembiring and Muhajir (2024), Scholars have identified six types of ethical principles that can guide shariah-compliant transaction activities: sincerity, brotherhood, truthfulness, trust, science and technology, and justice. The ban on interest is also found in Hebrew and Christian scripture. According to Warde (2010), Catholic monks in the medieval period believed interest rates were “particularly devastating to the poor.” So Franciscan monks offered loans, on which they made no profit. Housby (2013) indicates that several secular institutions, for example, offer "ethical" mutual funds that do not invest in tobacco or weapons. The author also notes that many non-Muslims see this industry as an attractive alternative to ethical banking and socially responsible investing.

As a result, these financial models are rapidly expanding, with an increasing number of new market entrants reaching over one billion consumers (Global Financial, 2022). This means that this

paradigm has an impact on achieving the SDGs and eradicating financial exclusivity in Muslim and non-Muslim countries alike. According to thorough studies conducted by Demirgüç-Kunt, A., et al. (2013), Shariah-based finance promotes social inclusion, environmental friendliness, and development. Similarly, according to Yusha'u, M. J., and Servaes, J. (Eds.) (2021), the IFB Financial Model can provide five routes for achieving the SDGs: financial stability and financial inclusion, financial inclusion (FI), reducing vulnerability, social and environmental activities, and infrastructure financing.

In addition, financial exclusion refers to measures that prevent certain social groups and individuals from participating in the organized financial system. Allen et al. (2016), In the present study, the term optimal financial inclusion is used as a proxy for IFB. Financial inclusivity, narrated and discussed in our analysis, is constructed on the operational concepts of FI given by Ozili P.K. (2020) and the Independent Evaluation Group (2023), which is one process that grants access to basic financial services supported by digital technology and provides basic financial services at a price that is affordable to the poorest and most excluded population, and such a price is similarly required to be enough to support the provision of such financial services with sustainability.

Also, based on the work of Cámara and Tuesta (2014), inclusive financial systems mean financial systems that maximize usage and access while minimizing involuntary financial exclusion (considering the context of diverse social-economic demographic variables such as age, gender, race, geographical region, disability, or financial capabilities of adults in Ethiopia). However, Kedir and Kouame (2022) argue that “access to an account” may not mean “use of an account. More importantly, financial literacy plays a key role in bridging the gap between users and Shariah-compliant financial services. Greater financial literacy promotes better understanding and acceptance of financial services, according to the OECD (2020) and Morgan, P. J. (2021). On the flip side, as argued by Ali, S. N. (2017), financial illiteracy can lead to low usage of Islamic banking products, showcasing a need for education programs tailored towards Islamic finance. According to Ozili, P. K. (2020) theory of FL, financially literate users have a willingness to participate in the formal financial sector. According to him, FL and financial capability are different concepts. The latter is about an individual's KSA (knowledge, skills, and attitude), and

ultimately, their behaviors and the ability to use financial products to their best benefit. But FL includes understanding the basic concepts and information.

The current shift toward digital financial literacy (DFL), which goes beyond basic financial literacy (FL), is being driven by fintech. Individual competency in understanding risks, digital financial risk controls, and consumer rights and redress procedures—which encompass the notions of DL and FL as postulated by Morgan P.J. et al. (2019)—as well as knowledge of digital financial products and services are all included in this. and the research of Tchamyou, V. S., et al. (2019) examined financial digitalization's impact on eradicating financial exclusivity in high-income inequality African states. DFL is a profound concept to apply as the current research strategy, according to the authors mentioned above. DFL is a crucial enabler that blends traditional and digital financial literacy to improve access to and utilization of digital financial services. Finally, digital transformation is on the policy agenda of the Ethiopian government, like many LDCs. Unvarying challenges in data security, privacy, and the digital divide can impede the effective use of technology in promoting financial inclusion (Quresh, M., et al., 2023).

Empirical Evidence: Influence of Digital Financial literacy on IFB Uses

Prior empirical studies are gray on how digital and financial literacy influences the use of Shariah-compliant financial services. Possumah et al. (2018) and Su'un et al. (2018) found that perceived understanding, benefit, innovativeness, religious promotion, customer attitude, and Sharia compliance significantly influence interest-free banking usage among Ghana's three major religious groups, including non-Muslim respondents. Growing empirical evidence suggests that increased individual awareness and knowledge of Shariah-compliant products promotes the steady growth and expansion of investment goods and services to meet rising demand.

For example, Muslichah and Sanusi (2019) found that FL had a stronger influence on business participants' intentions to utilize shariah-compliant banking services than religiosity and attitude. In addition, the findings of Astuti (2023) show a positive and significant relationship between FL and commitment to the interests of Islamic banking students. Similarly, Allgood and Walstad (2016) found a strong relationship between financial literacy and confidence in financial decision-making. Studies by Lusardi and Mitchell (2014) and Fernandes et al. (2014) show that positive

attitudes contribute to financial inclusion by increasing the search for and use of financial products and services.

supported by the studies of Ozili K.P. (2021) Albaity, M., & Rahman, M. (2019). Higher financial literacy levels are positively correlated to the use of financial services, but this relationship changes when there is a positive attitude towards Islamic banks.

Consequently, it is anticipated that financial literacy and IFB financial inclusion will positively correlate, per the studies mentioned above. Today, as a result of increased FinTech, people are switching to DFL, not FL. Nurkholik, A. (2024), Dogra, P., & Kaushal, A. (2023); and Hargitay and Hinnant (2008) found that digital literacy (DL) has a positive effect on intentions to use financial products and services. They highlighted that deep learning is very useful in predicting people's digital activities, such as searching for information and using financial products and services. According to research by Asad, R., et al. (2023) and Usman and Hussain (2022), user attitude is the most crucial element in the adoption of fintech, and user creativity is a key predictor, in both direct and indirect ways. Also, according to Hoque, M., et al. (22022), FL does not have a significant effect on IFB acceptance, but ethical practices, religious values, and institutional reputations impact attitudes toward Shariah-compliant banking services.

Regarding the influence of demographic, socioeconomic, and geographic factors on IFB acceptances, Demiurge-Kunt et al. (2013) and Zins and Weill (2016) found significant inequalities between Muslims and non-Muslims due to demographic and socioeconomic variables. The same finding was made by Potrich et al. (2015): lower income and education levels are associated with lower financial literacy and reduced use of shariah-compliance banking. As revealed by studies (Datta, P. B., & Manjula, R. (2019); Uddin, S., et al. (2020); Amaroh et al. (2019); Demirgüç-Kunt et al. (2015) and (2013)), adult financial well-being is also influenced by factors like gender, income, education, and age, with education and income having a greater impact. While a lack of shariah financial literacy negatively influences acceptance of IFB financial services (Daradkah et al., 2020).

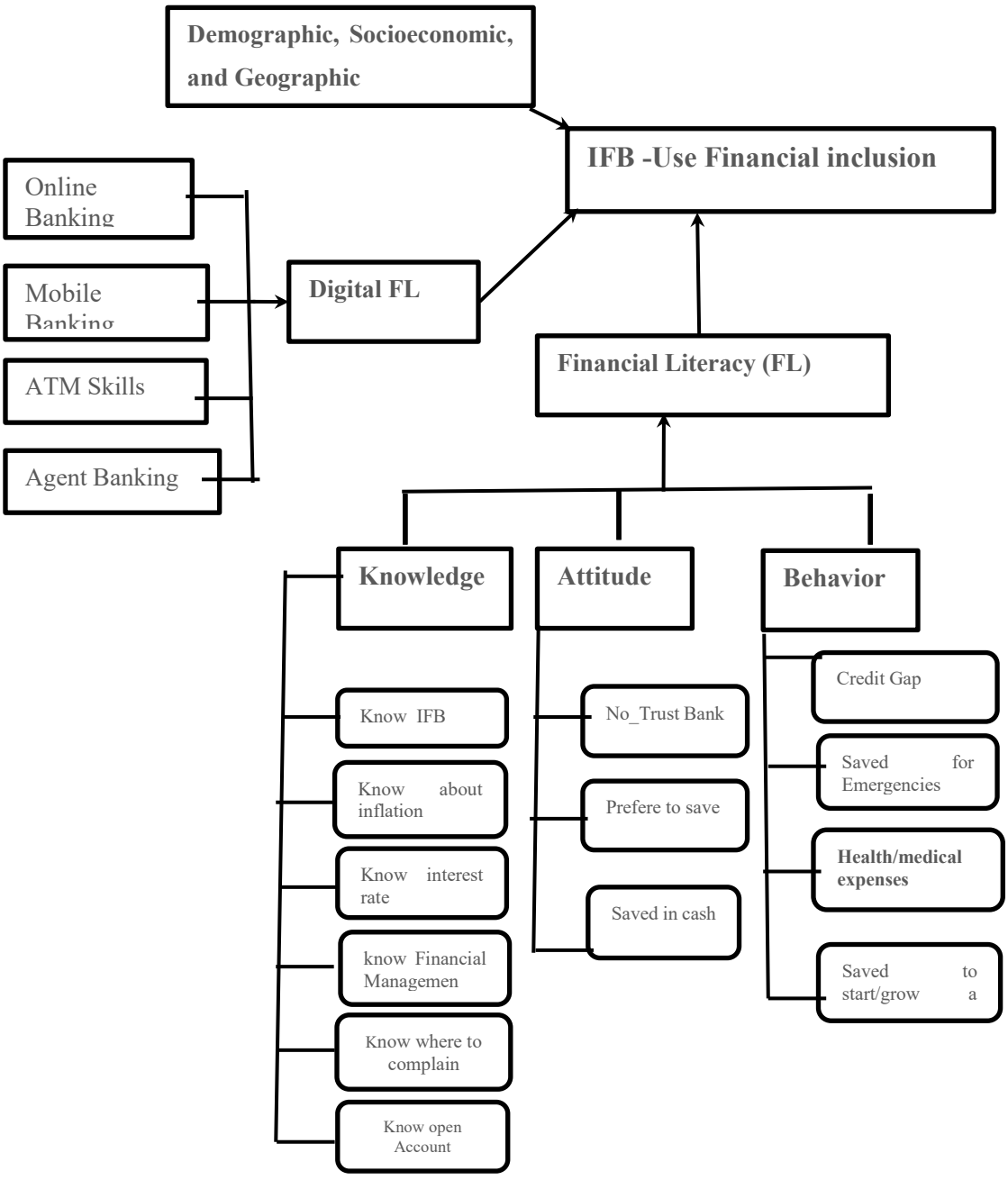
A similar study conclusion by Aman et al. (2021) highlighted the importance of community awareness, religious connotations, and government regulatory support in influencing IFB acceptance in Ethiopia, drawing on successful examples from other countries. There have been only a few notable attempts to study the influence of DFL on IFB service usage for inclusive

financial systems in Sub-Saharan Africa (SSA), particularly in Ethiopia, which has a highly diverse adult population. Given the recent rise in policy efforts to enhance financial inclusion aligned with digitization while taking national circumstances into account, it is imperative to study the influence of DFL on IFB service use in the Ethiopian adult context.

Finally, the CFW presented in Figure 1 was developed based on an existing deep theoretical and empirical literature review showing expected relations between current study variables and was mostly guided by the studies of Golden and Cordie (2022); Ozili, P. K. (2020); Ozili, K. P. (2021); and Morgan, P.J. et al. (2019). Accordingly, the following two key primary hypotheses (see more in Table 1) were evaluated in the context of Ethiopia under Citrus Paribus: The first hypothesis (H1) is that digital financial literacy (DFL) has significantly positive influences on adults' use of IFB services. Secondly (H2): Financial literacy (FL) has a significant positive influence on IFB service usage.

Figure 1:

Conceptual Framework



Source: Authors designed based on tested concepts by Golden and Cordie (2022); Setiawan et al (2021), Ozili K.P, (2021), and Yang, J., et al (2020).

The Data and Estimation Strategy

Type of data and study variables measurements:

The study uses data from the 2018–19 ESS-FI Module, a household survey by the Ethiopian Central Statistics Agency with WB aimed at measuring progress in Ethiopia's Financial Inclusion Strategy (NFIS). It focuses on access to finance, account ownership, financial service use (including IFB use), digital financial services (ATMs, mobile money, online banking, debit cards, and credit cards), and digital and financial literacy (knowledge, attitudes, and behaviors). The survey has representatives from 6,700 households across nine regions, two cities, rural and urban areas, and 565 enumeration areas, involving 15,344 adults.

This clustered data also includes 5,342 diverse individual insights. For example, an adult response to the question of the use of financial services: "In the last 12 months, have you used any of the following services (ATM/debit card, online banking, mobile banking, agent banking, interest-free banking)?" These responses from financial service users include both Muslims and non-Muslims. Out of the 5342, 3310 individuals are Orthodox, 733 are Protestants, 1231 are Muslims, and the remaining 68 are from other religious groups, including Catholics, Wakefeta, and pagans. This means that the adults selected as the unit of analysis represent a diverse religious group. This ESS 2018/19 data, particularly the FI module, is preferred for this research due to its collaborative nature, ensuring high-quality data collection, representative sampling, contextually structured comprehensive questionnaire design, and linkage with detailed adult information, making it a valuable resource for studying the socioeconomic conditions and financial inclusion in Ethiopia.

Table 1 below presents the study's selected variables, descriptions, and hypothesized signs of the parameters with relevant literature support. Specifically, the researchers operationally defined the dependent variable, the use of IFB service, as a binary variable with a leveled value of 1 if the adult has used IFB products and services during the specified period and 0 otherwise. Financial literacy (FL) is multidimensional and measured by including a linear combination of an individual's financial knowledge, attitude, and behavior (OECD, 2018), and adult DFL is measured by digital service usage skills indicators (Ravikumur et al., 2022), such as internet banking, mobile banking, ATM use, and agent banking, as explanatory indicators of DFL score levels among Ethiopian adults.

Following the methodology employed by the OECD/INFE 2023 and Yang, J., et al. (2020), the indicators used to measure the financial literacy sub-dimension in the study surveys include the following: First, FL's financial knowledge sub-dimension indicator is measured by the understanding of IFB services, inflation, interest, awareness of financial management, knowledge of where to file complaints, and how to open an account at a formal financial institution.

Table 1:

Description and Expected Hypotheses Sign (+/-) of the Variables Influencing IFB Uses:

Variables	Descriptions	Hypothesis Sign	Sources
Knowledge (FK)	It is a sub-dimension of the FL variable measured by the PCA score of the individual answers to financial knowledge questions.	+	Toronto Centre (2022), OECD (2020), OECD/INFE (2018), Ozili, P. K. (2021), and Bunyamin & Mutlu (2017).
Behavior (FB)	It is a sub-dimension of the FL variable measured by the PCA score of the individual answers to financial Behavior questions.	+	Toronto Centre (2022), OECD (2020), OECD/INFE (2018), Ozili, P. K. (2021), and Bunyamin & Mutlu (2017).
Attitude (FA)	It is a sub-dimension of the FL variable measured by the PCA score of the individual answers to financial attitude questions.	+	OECD (2022), OECD/INFE(2023) , Ozili, P. K. (2021),and Bunyamin & Mutlu, 2017.
Financial Literacy_score(i)	It is a key explanatory variable measured by the PCA score of the individual aggregated FL scores.	+	Toronto Centre (2022), OECD (2022), OECD/INFE (2023), Ozili, P. K. (2021), and Bunyamin & Mutlu (2017).
Digital Financial Literacy_score(I)	It is second a key explanatory variable measured by the PCA score of the individual DFL	+	OECD (2020) and Morgan, P. J. (2021). Golden and Cordie (2022),Setiawanet et al. (2021)
Female	1 if the person is female, 0 otherwise.	-/+	Khmous, D., & Besim, M. (2020); Datta, P. B., & Manjula, R. (2019); and Abedifar et al. (2016)

Age	Age in number of years and its square	+	Khmous, D., & Besim, M. (2020), Zşuca, E. A. (2019), and Desalegn & Yemataw (2017)
Age squared	Square of the age of the person	-	Khmous, D., & Besim, M. (2020), Zşuca, E. A. (2019), and Desalegn & Yemataw (2017)
Financial capability	a proxy for income, indicating on average the person's ability to save 600 Birr at least per year; considered financially capable, 0 otherwise.	+	Giday, H. G. (2023); Lyons, A., et al. (2020); Datta, P. B., & Manjula, R. (2019); and Desalegn & Yemataw (2017)
Education	The number of years of schooling attended by the individual. It is a continuous variable.	+	Datta, P. B., & Manjula, R. (2019); and Uddin, S., et al. (2020);
Shock-resilience	1 if worried about being able to cover unexpected expenses and 0 otherwise	+/_	Lyons, A., et al (2020), Giday, H. G. (2023), and Desalegn & Yemataw, (2017)
Informal (Equb)	1 if an individual informally SAVE CASH for EQUB and 0 other	+/-	Coulibaly, M., & Sirpé, G. (2023), Lakew, T., & Azadi, H. (2020) and Abdesamed, K., & Wahab, K. (2015)
Unemployment	1 if the respondent is unemployed and 0 if otherwise.	_	Lyons, A., et al (2020), Giday, H. G. (2023), and Desalegn & Yemataw, 2017
Own Mobile Phone	1 if the individual has a mobile phone and 0 if otherwise.	+	Golden and Cordie (2022), Setiawanet et al. (2021), and Morgan, P. J. (2021). Golden and Cordie (2022), Setiawanet et al., OECD (2020), and Lyons, A., et al. (2020).
Religious	Categorical variable: e.g. 1 if the respondent self-identifies as	+/-	Giday, H. G. (2023), Desalegn & Yemataw, 2017, and Abedifar et al., 2016)

	Muslim, other 0, 1 if the respondent self-identifies as EOTC, other 0.		
Rural resident	1 if the person identifies as a Rural resident, other 0	_	Yang, J., et al. (2020), Shinkafi, A. (2019), and Desalegn & Yemataw (2017).
Urban resident	1 if the person identifies as an Urban resident, other 0	+	Yang, J., et al. (2020), Shinkafi, A. (2019), and Desalegn & Yemataw (2017).
Distance from FFI	The distance of the ith adult from the nearest FFI in KM. It is a continuous variable variation in closeness to FFI.	+	Yang, J., et al. (2020), and Abdallah et al. (2024)
Region	Region category variable to measure disparity of Financial inclusion via IFB use (Tigray, Afar, Amhara, Oromia Somali., SNNP, Addis Ababa & DD and others	+/-	Yang, J., et al. (2020), Abedifar et al. (2015, and Desalegn & Yemataw (2017).

Source: Authors compiled based on Ethiopia ESS 18/19 variables and Prior literature,2024

As shown in CFW Figure 1, financial attitude is a sub-dimension measured by adult responses to bank trust, formal versus informal saving preferences, and attitude toward cash savings at home questions. Then, financial behavior was measured in adult responses to the questions about the credit gap, saving behavior for emergencies, medical and health expenses, and saving behavior to start or grow a business. Further, the above key explanatory variables, such as the FL mean score, DFL score, and the three FL indicator sub-dimensions, are computed using the PCA method using Stata 15 software. Finally, many demographic, socioeconomic, and geographic householders provide explanatory factors for the demand for IFB services and the hypothesized signs of the parameters of the model defined as described in Table 1:

Methods of Data Analysis:

The PCA is a statistical method for minimizing the dimensions of a large multidimensional variable while maintaining the majority of its information. (Abdi and Williams, 2010; Al-Kandari and Jolliffe, 2005). As a result, the PCs are linear combinations of the original variables, weighted according to how they contribute to explaining variance in a specific orthogonal dimension. PCA is suitable for investigating financial literacy, digital literacy, and financial service use using clustered data. It ensures the validity of measurement scales and can be used as predictors in regression models to examine the effects of financial services, particularly IFB financial products, in prior adult literacy studies (Bates et al., 2015; Gelman & Hill, 2007). In this study, two stages of PCA are used to compute the means score of FL and DFL using the methods of Camara and Tuesta (2014), Mukherjee and Sood (2020), and Nguyen (2020).

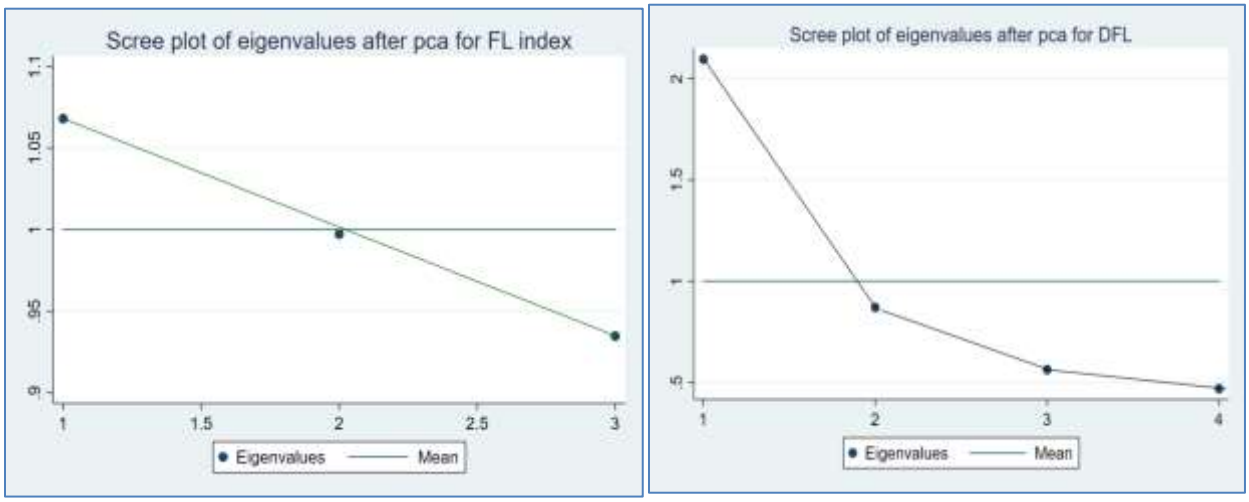
The first stage of the PCA estimates the three variables of financial literacy (FL), which are multidimensional and include a linear combination of an individual's financial knowledge, attitude, and behavior (OECD, 2018). Following the tested examples of Prasad et al. (2018) and Ravikumur et al. (2022), adult DFS scores are calculated by digital service usage skills indicators, such as internet banking, mobile banking, ATM use, and agent banking, as explanatory indicators of DFL score levels among Ethiopian adults. In the second stage, we combined the three-dimension score indicators to get an aggregate financial literacy score by computing a weighted linear combination of the dimension score from the first stage. Furthermore, the weights were calculated using a multivariate PCA min-max technique. This study employed the KMO sample adequacy test and Eigenvalue screen plot methods to assess the reliability and power of FL and DFL scores. According to Kaiser (1974), if the KMO test value is more than or equal to 0.5, the test confirms the acceptable sample size and supports the adoption of PCA.

As reported by Lyons, A., & Kass-Hanna, J. (2021) and Lusardi and Mitchel (2014), financial literacy and DFL scores are multidimensional components, so they are best represented by two underlying dimensions or indicators rather than a single index or score. To measure adult literacy, the OECD (2018) and Lusardi & Mitchell (2014) used a scoring system where individuals are categorized based on their number of correct answers to financial literacy questions. such as a score above 3 out of 5 to indicate positive attitudes or behaviors, and also a score of 5 or more

correct answers out of 7 to be considered financially literate. while others (Mandell, 2009) have used more nuanced categorizations into levels such as poor, fair, good, very good, and exceptional. Financial literacy, knowledge, behavior, and attitude scores of more developed economies are higher than those of the least developed countries (OECD, 2018; Mandell, 2009). which implies there is no clear consensus on a cut-off score rate for financial literacy, as it likely depends on the specific context and the level of knowledge deemed necessary for financial well-being. However, the general practices show that a score above 50% is mostly seen as a baseline for financial literacy, with higher scores indicating greater literacy OECD (2022), OECD/INFE 2020, and 2021. In this research, PCA analysis results in Table 2 show these selected PC components meet the basic requirements of FL and DFL indicator measurement practices. For example, the KMO measure value for the FL score index of 0.501 and the DFL index of 0.692 is KMO > 0.5. As a result, the study sample is adequate, and the researchers may use PCA score indicators to analyze the adult literacy status. Furthermore, double-check that researchers have tested an eigenvalue screen plot. An eigenvalue screen plot helps in decision-making by visualizing eigenvectors on a plot for simple analysis. So, Figure 2. This clearly illustrates that at inflection points, retention of two components from FL score indicators and DFL, as adult literacy measurements, have a strong connection and are positively correlated.

Figure 2:

Screen plot of the eigenvalues of FL and DFL



Source: Drawn by the authors on Stata 15,2024

Guided by the methods used by Lever, J. (2017) and mentioned above, the eigenvalue rule was used to figure out the members of the major components. The first-stage PCA result for the financial knowledge sub-dimension indicator, knowledge of IFB services (0.36) and adult knowledge of inflation (0.17), has the highest weighted score. One can see that, for these two indicators, each dimension has an eigenvalue greater than 1. It is important to notice that for the knowledge dimension, these two components cumulatively explain 52.7% of the variance in adult financial literacy.

Similarly, the indicator variables No_Trust_Banks and Where prefer to save in the current research have eigenvalues greater than one and have the necessary proof to utilize these components to explain changes in financial attitudes. Additionally, Table 2 demonstrates that each of the two PCs in the financial behavior sub-dimension—1.083 (credit gap) and 1.017 (saved for emergencies)—reports higher 1 eigenvalue, indicating that the data is more valid for financial behavior analysis.

Table 2:

The KMO and Eigenvectors of sub-dimension FL scores

1. Financial Knowledge				**2. Financial Attitude**			
Variable	CUM	Eigenvalue	KMO	Variable	CUM	Eigenvalue	KMO
Know_IFB service	0.359	2.157	0.744	No_Trust_Bank	0.333	1.104	0.493
Know_Inflation	0.527	1.006	0.735	Prefer informal	0.667	1.003	0.495
Know_Interest	0.679	0.911	0.745	Saved in Cash	1.000	0.893	0.497
Financial Management	0.795	0.695	0.702				0.495
KNOW where to complain	0.900	0.633	0.759				
Know how to open an Account	1.000	0.598	0.757				
3. Financial behavior				**4 Financial Literacy score**			
Variables	Cum	Eigenvalue	KMO	Variables	Cum	Eigenvalue	KMO
Credit gap	0.25	1.083	0.52	Knowledge	0.333	1.068	0.501
Saved for emergence	0.50	1.017	0.49	Attitude	0.667	0.977	0.503
Saved for medical	0.75	0.996	0.484	Behavior	1.000	0.935	0.501
SAVED_Start Business	1.000	0.904	0.486				0.501

Source(s): Calculated by the authors using PCA on Stata 15,2024

Finally, Table 3 also shows the weights for the indicators in the DFL dimension. The first three indicators can predict individual-level DFL of 88.3% (online banking skills, mobile banking skills, and use of ATMs). The use of online banking is the most important indicator in defining the DFL score dimension, with a proportion of 0.524. Therefore, adult digital financial products usage

skills, particularly the use of online banking, are a strong explanatory indicator variable for measuring as a proxy for DFL skills.

Table 3:

The KMO and Eigenvectors of DFL scores

Variable	Weight	Cum	Eigenvalue	KMO
Online Banking skills	0.524	0.524	2.067	0.683
Mobile Banking skills	0.218	0.742	0.870	0.678
ATM skills	0.141	0.883	0.564	0.704
Agent Banking	0.117	1.000	0.470	0.717
				0.692

Source(s): Calculated by the authors using PCA on Stata 15,2024

Econometrics models Specification: IFB usage

The goal of this study is to analyze the influence of FL and DFL on IFB use among Ethiopian adults. In this scenario, along with digital and FL as independent variables, the dependent variable, which is IFB usage by adults, is expected to be influenced by a variety of demographic and socioeconomic characteristics. The nature of our survey data is that it contains multilevel data structures, with observations nested within clusters such as adults by geographical region, location (urban or rural), religious affiliation, gender, and adult in the household. However, since the dependent variable of the model, the use of IFBs (interest-free banking) by adults, is a binary variable that can take on only two values (1 or 0), the model can be specified as a binary logit model. Despite this, in this study, each observation of the use of IFB by adults is not plausible to assume to be independent of one another, as the actions of adults in the same household might be correlated.

According to Williams, R. (2018), Kilian, and Kelava (2023), for cluster data types, mixed-effects models are a common strategy for resolving inbuilt estimation challenges. These methods, also known as hierarchical models, are advanced econometric modeling approaches that incorporate both fixed and random effects in the model analysis.

The generic linear mixed-effect models (LMM), Eq_1, include fixed effects and deviations that are equivalent to traditional OLS standard regression coefficients and are calculated directly, as well as random effects that are assumed based on their estimated variances and covariance. The LMM model specification equation is expressed as follows:

$$\text{IFB\_usage\_i} = \beta 1 \text{FL}_\text{i} + \beta 2 \text{DFL}_\text{i} + \text{Zui} + \epsilon \text{i} \_\_\_\_\_ \text{Eq\_1}$$

Where individual adults are identified by i; or adult observations is the interest-free banking service usage for the i-th individual, DFL and FL are the design matrix for the fixed effect variables, β1 and β2 are the vectors of fixed effect coefficients that measure the extent to which DFL and FL score affect IFB uses, Zi is the design matrix a vector for the random effect variables that contains demographic, socioeconomic, and geographic attributes of the i-th individual, ui is the vector of random effect coefficients, and is the residual error term for the i-th individual. In the current model, the null hypothesis is that adult actions randomly vary within the same HHs but are the same (fixed) across other HHs. The assumption is that ϵi = i.i.d. $N(0, \sigma 2)$. which means adult independence hypothesis Ho $\beta \neq 0$ and H1 $\beta = 0$.

However, in our clustered data nature, each observation of adult IFB use is unlikely to be independent of one another because the activities of adults in the same place or household may be correlated or dependent. These multilevel hierarchical cluster data can violate assumptions of independence for adults, resulting in biased estimates and incorrect inferences. Greene (2018) reaffirms that the endogeneity problem is common in economics and behavioral finance and could arise due to reverse causality.

Thus, the primary reason for using fixed effects in mixed-effect modeling is to control for unobserved cluster-specific effects, which can help address endogeneity concerns for relevant omitted variables (Kilian and Kelava, 2023; Leszczensky and Wolbring, 2022). According to the authors aforementioned, mixed-effects modeling implies that the explanatory factors are uncorrelated with the error term and that any association between the explanatory variables and the error term is caused by unobserved cluster-specific effects. So, to address these issues, the researchers used the restricted maximum likelihood (REML) specification approach, as stated in Eq. 2. The intercept model of adult IFB use is objectively assessed by clustering individual adult

random variances across households while fixed within the same HHs. The estimation was done using maximum likelihood. This is a mathematical representation of the study modeling equations:

$$\text{IFB\_usage\_i} = \beta 1 \text{FL}_{\text{i}} + \beta 2 \text{DFL}_{\text{i}} + \text{Z ui} + \epsilon \text{i} \quad \text{\_\_\_\_\_Eq\_2}$$

According to a mixed effect modeling specification requirement that predictor variables do not vary within residuals, residual errors ρi in REML are assumed to be randomly correlated across household clusters. This means that the null hypothesis in this modeling method is that adult action is the same (fixed) within the same household while randomly varying across other households. That is, within the same household, adult dependency assumptions hypotheses Ho $\beta=0$ and H1 $\beta\neq0$). Furthermore, for better modeling robustness, choose between logistic and mixed effects. For comparative purposes, simple logit-probit modeling estimations by maximum likelihood methods were also included in the output result analysis section.

Results and Discussions

Descriptive Statistics Analysis:

Summary statistics of PCA results of FL and DFL scores for each sub-dimension of FL are presented below in Table 4.

Table 4:

Summary Statistics: Financial and Digital Literacy Scores of Adults in Ethiopia.

Variable	Financial Knowledge_Score	Financial Behavior_Score	Financial Attitude_Score	Financial Literacy_Score	Digital Financial Literacy_score
Mean	6.03e-09	8.13E-09	-7.80E-09	-2.24e-10	-1.46e-08
Std. Dev.	0.580	0.451	0.573	0.565	1

Source(s): Calculated by the authors using PCA on Stata 15,2024

The PCA scores summary of descriptive statistics results shows that the mean scores of financial knowledge and financial behavior aspects of FL for adults in Ethiopia are positive. On the other hand, the mean scores of the aggregate FL score and attitudes toward formal financial institutions (FFIs) and financial activity among Ethiopian adults are revealed to be negative. Furthermore, the standard deviations of financial knowledge, attitude, and aggregated averages of FL are higher (>.0.5) than the standard variances of financial behavior scores. This implies that there is more diversity in adults' FL on FFI and financial concepts. It is critical to interpret these mean scores of financial knowledge and behavior toward financial services and financial activity. This positive behavior encourages them to actively seek out and utilize financial products and services, contributing to their financial inclusion. Equally important is positive financial knowledge. Adults are more likely to engage in responsible practices and enhance their inclusion.

Adult attitude is measured by respondents who answered financial attitude questions such as if they had any failed credit financing trials and their attitude toward saving for emergencies, medical expenses, and starting a business. The result reflects the bad experiences of adult individuals. Similarly, research results for the aggregated FL score

indicate negatives and below one by mean of the aggregated dimensions, which confirms prior empirical claims of Kass-Hanna, J., et al. (2022) that Ethiopian adults' FL levels have a poor track record even compared to the sub-Saharan average. Also, the mean score of the PCA-predicted DFL of adults in Ethiopia is shown as negative, indicating from our survey data a low level of DL literacy among adults in the country.

Bivariate Relationship Analysis:

As seen in Table 5 below, the P-values of the t-test for the difference in mean scores of the aggregate FL score as well as all dimensions of FL are less than 0.05 for the adult group in place, i.e., rural-urban effects. This implies that in Ethiopia, there is a statistically significant difference in mean scores of the aggregate FL as well as all dimensions of the FL of adults between urban and rural areas of the country. Similarly, the mean scores of DFL show there is a statistically significant difference between urban and rural areas.

Table 5

Mean IFB use and FL Scores of Adults in Ethiopia by Urban and Rural Areas.

Variable (at their Mean Score)	Mean Urban	Mean Rural	Diff.	St Err	t value	P-value
Financial Knowledge	.132	-.155	.288	.009	30.75	0.0000
Financial Attitude	.055	-.065	.12	.009	12.90	0.0000
Financial behavior	.093	-.11	.203	.007	28.70	0.0000
Financial literacy	.159	-.19	.348	.009	38.65	0.0000
Digital Financial Literacy	1.035	1.006	.029	.002	12.95	0.0000
IFB usage	1.874	1.863	.011	.012	0.85	0.3850

Source: Authors computation using PCAs from ESS 2018/2019 data,2024

Relative to urban and rural residents, adults scored a low mean of DL. This indicates that rural adults in Ethiopia have marginalized literacy (both digital and financial) compared to their urban counterparts. Abebe and Deneke (2015) and Ziyn Engdasew, Z. E. (2012) reported the same results. As they revealed, rural communities in Ethiopia suffer major

barriers to education and training opportunities compared to their urban counterparts. However, the P-values of the t-test of IFB usage, since these P-values are larger than 0.05, imply no significant disparity in the use of IFB financial services between urban and rural.

In addition to the difference in literacy and IFB use among adults between rural and urban areas of Ethiopia, the researcher has assessed whether the difference exists gender-wise. This may help to identify whether gender discrimination in IFB Finance and FL of adults exists in the country. The researcher compared the mean scores of FL and IFB Finance in Ethiopia to determine gender differences in literacy. Table 6 presents the results of t-tests.

Table 6:

Mean IFB Use, DFL, and FL Scores of Adults in Ethiopia by Sex

Variables (at their mean score)	Mean Male	Mean Female	Diff	St Err	t value	P-value
Financial knowledge	.018	-.016	.034	.009	3.6	0.001
Financial attitude	.003	-.003	.005	.009	.5	0.606
Financial behavior	.021	-.018	.038	.007	5.15	0.000
Financial literacy	.03	-.026	.056	.009	5.85	0.000
Digital Financial Literacy	1.03	1.012	.018	.003	7.6	0.000
IFB usage	1.862	1.885	-.022	.009	-2.45	0.140

Source: Authors computation using ESS 2018/2019 data,2024

The data insight evidence reveals that, compared to males, the mean of adult females computed negative for financial attitude (-0.003), indicating males have a better positive financial attitude. Surprisingly, for the mean of IFB use, females (1.885) and adults have slightly higher IFB use than males (1.862). However, the P-values of the t-test result in mean scores of aggregate attitudes and IFB use between male and female adults in Ethiopia are p values of 0.606 and 0.14, respectively. Since these P-values are larger than 0.05, the researchers failed to reject the null hypothesis of no significant difference in mean scores of aggregate attitudes and IFB use between male and female adults in Ethiopia at the 5% level of significance.

However, the p-values of the t-test for the presence of statistically significant differences in all dimensions of FL and DFL, including FL, knowledge, and financial behavior, between male and female adults in Ethiopia are less than 0.05. This indicates the presence of statistically significant differences in the means of FL and other FL and DFL measures between Ethiopian male and female adults at the 5% significance level. Furthermore, these differences must be positive and significant. This means that the mean scores of Ethiopian female adults for knowledge, behavior, and all combined FL and DFL scores are significantly lower than the mean scores of their male counterparts. Our result supports the claim that women's financial literacy is a key determinant of IFB service use among men and women. Efforts to improve women's FL can increase gender and cultural diversity and inclusivity (Hasan and Hoque, 2021; Khan et al., 2019).

As one can see in the result in Table 7, adults in Addis Ababa have the highest positive FL mean scores (0.252), followed by those in Tigray (0.103). A statistically significant low mean FL score was revealed for Somali (-0.088), Oromia (-0.088), Afar (-0.072), and SNNP (-0.042). This analysis of single-year (2018–19) observation of survey data indicates that, compared to adults in Addis Ababa.

Table 7:

FL score by Geographical regions

Region	Mean1	Mean2	dif	St Err	t value	p-value
Addis Ababa	-.04	.252	-.29	.015	-18.75	0.0000
Tigray	-.01	.103	-.113	.015	-7.3	0.0000
Harar	-.002	.019	-.021	.019	-1.1	0.2790
Gambela	-.001	.011	-.011	.019	-.6	0.5380
Benishangu Gumuz	-.001	.008	-.009	.018	-.5	0.6350
Dire-Dawa	.001	-.009	.01	.015	.65	0.5150
Amhara	.002	-.017	.018	.014	1.35	0.1780
SNNP	.005	-.042	.046	.015	3.2	0.0020
Afar	.005	-.072	.077	.017	4.55	0.0000
Oromia	.011	-.088	.1	.015	6.45	0.0000
Somali	.027	-.261	.288	.015	19.65	0.0000
Dummy *Mean1=No **Mean2=Yes						

Source: Authors computation using ESS 2018/2019 data,2024

Additionally, the study investigates the means variance of the DFL and FL scores of adults by their religious affiliations. This may be necessary since IFB financial inclusion calls for providing financial services and products that align with the community's social and religious values. Therefore, identifying the differences between Ethiopian adult religious affiliations may be crucial in determining which regions are most distant from Ethiopia's current financial system and, subsequently, in formulating a suitable policy response.

Table 8:

Mean FL and DFL scores by religious

Religion	Mean1	Mean2	Diff.	St Err	t value	p-value
EOTC	-.079	.093	-.172	.009	-18.2	0.0009
Protestant	-.003	.016	-.019	.013	-1.55	.127
Muslims	.067	-.112	.178	.009	18.65	0.0000
Catholic	.003	-.252	.255	.071	3.6	.001
Others	.001	-.105	.106	.05	2.1	.036
Mean Digital Financial literacy score by Religious						
EOTC	.035	-.022	.057	.028	2.05	.041
Protestant	.005	-.034	.04	.042	.95	.343
Muslims	-.021	.069	-.089	.03	-3	.003
Catholic	-.002	.256	-.258	.014	-18.55	0
Others	0	.057	-.057	.199	-.3	.777
Dummy *Mean1=No **Mean2=yes						

Source: Authors computation using ESS 2018/2019 data,2024

As shown in Table 8, the p-values of the t-test for the presence of statistically significant differences by FL score by religion are less than 0.05, except for individual adults from protestant religious groups. This result particularly indicates there is a statistically significant difference in mean financial and digital literacy scores among adults of Muslim and non-Muslim religious affiliations at the 5% significance level.

Regression Analysis:

Table 9 below displays the econometric regression results regarding the influence of DFL and FL on IFB service usage. The Logit-probit models (columns 2 and 3) and then the linear mixed effect model (column 4) were estimated consecutively, followed by fitting within householder random variance controlled maximum likelihood (REML columns 5).

Table 9:
Econometrics Modeling of IFB usage (Dependent variable)

Variables (at their mean score)	Logit	Probit	Linear Mixed Effect (Random)	REML (within HH fixed effect)
Digital Financial Literacy	2.693*** (13.25)	1.386***(13.16)	0.270***(14.81)	0.255***(14.67)
Financial Literacy	0.884***(7.07)	0.445***(6.91)	0.0465***(6.54)	0.0441***(6.13)
Knowledge	0.690**(3.07)	0.319** (2.65)	0.0427** (2.8)	0.0359* (2.33)
Behavior	0.121*(2.04)	0.0728*(2.26)	0.00778(1.83)	0.00593(1.41)
Attitude	-0.00744(-0.11)	-0.000984 (-0.03)	0.000244 (-0.05)	-0.00172 (-0.32)
				Demographic, socioeconomic, and geographic effects
SEX	0.248(1.86)	0.138(1.9)	0.0177(1.85)	0.0183*(2.17)
AGE	-0.0268(-1.11)	-0.0108(-0.81)	-0.00205(-1.15)	-0.00108(-0.64)
age2	0.000271(0.99)	0.000107(0.7)	0.000022(1.09)	0.000011(0.58)
Distance from _FFI	-0.00227(-1.54)	-0.00126(-1.49)	-0.00018(-1.49)	-0.00023(-1.65)
Rural resident	-0.0613(-0.36)	-0.0431(-0.45)	-0.00519(-0.39)	-0.0065(-0.45)
Shock	0.126(1.0)	0.0745(1.08)	0.0126(1.38)	0.0141(1.51)
Informal (Equb)	0.540***(-3.4)	0.280**(-3.23)	0.040***(-3.61)	0.037***(-3.47)
Own mobile	0.0116(1.07)	0.00654(1.11)	0.000879(1.01)	0.000545(0.63)
Unemployed	-0.117(-0.88)	-0.0517(-0.71)	-0.0115(-1.18)	-0.00641(-0.68)
Financial capability	-0.0633(-0.15)	-0.0308(-0.13)	0.0111(0.4)	0.0156(.57)
Education	0.0118(1.96)	0.00702*(2.19)	0.000715(1.65)	0.000699(1.63)
				Religion _EOTC base
Catholic	0(.)	0(.)	-0.0249(-0.52)	-0.027(-0.58)
Protestant	-0.437(-1.55)	-0.19(-1.41)	-0.0208(-1.42)	-0.0246(-1.52)
Muslim	3.42***(20.17)	1.82***(21.84)	0.40***(32.7)	0.40***(28.9)
Others (Pegan and Waketeta)	0.818(0.74)	0.427(0.79)	0.0167(0.22)	0.017(0.22)
				Region (Addis Ababa base)
Afar	0.625(1.65)	0.327(1.66)	0.0463(1.69)	0.0512(1.69)

Amhara	-0.0568(-0.15)	-0.0348(-0.18)	-0.00316(-0.16)	-0.00585(-0.26)
Oromia	1.655***(4.68)	0.865***(4.84)	0.128***(5.68)	0.136***(5.45)
Somali	0.606(1.36)	0.304(1.26)	0.0279(0.73)	0.0445(1.05)
BG	0.285(0.69)	0.114(0.53)	0.0018(0.07)	0.000689(0.02)
SNNP	0.787*(2.04)	0.344(1.73)	0.0470*(2)	0.0434(1.68)
Gambella	0.305(0.72)	0.125(0.58)	0.0109(0.47)	0.0106(0.41)
Harar	0.783*(2.31)	0.396*(2.29)	0.0605**(2.77)	0.0534*(2.17)
Tigray	-0.468(-1.42)	-0.278(-1.70)	-0.0327(-1.88)	-0.0294(-1.48)
Dire Dawa	0.538(1.63)	0.273(1.63)	0.0271(1.35)	0.0266(1.17)
_cons	-5.734***(-7.51)	-3.090***(-7.60)	-0.0864(-1.66)	-0.100*(-1.97)
N	3757	3757	3791	3791
Pseudo R2	0.4136	0.4104		
LR Chi2(29)	1228	1218.78		
Log-likelihood	-870.7	-875.34	-485.33	-359.42
Wald chi2(30)			2006	1656
AIC	1801.4	1810.7	1036.7	784.8
BIC	1988.4	1997.6	1242.6	990.8

N.B: t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source. Stata Output,2024

Robustness Testing:

The post-estimation additional diagnostic test results of the models are shown in Table 9 and Table 10 for reference. Tables 10 exhibit the models' post-estimation extra-diagnostic test results. As demonstrated in nested models. Table 9 shows that the fitted fixed mixed-effects REML (columns 5) is a better estimator than all other models, achieving the lowest desired values of Akaike's Information Criterion (AIC) (784.8) and Bayesian Information Criterion (BIC) (990.8). This implies that mixed-effects modeling is preferred over the logistic regression results of logit and probity.

According to McNeish and Kelley, 2019: McNeish, D. (2017) and McNeish, D., & Stapleton, L. M. (2016), the advanced performance of mixed effects modeling in the context of clustered survey data originates from its ability to appropriately handle correlation, flexibility in modeling hierarchical structures, robustness to unequal cluster

sizes, improved variance estimation, and the ability to incorporate multiple levels of covariates. These benefits contribute to more trustworthy and valid conclusions in this research investigation that used clustered data.

Table 10:

Result from robustness Testing

Random-effects Parameters		Estimate Std. Err.	[95% Conf. Interval]
Household_id: Identity			
	var(_cons)	.0371133 .002379	.0327316 .0420816
	var (Residual)	.0402785 .0017299	.0370267 .0438158
LR test vs. linear model: chibar2(01) = 251.84			Prob >= chibar2 = 0.0000

Source: Stata Output,2024

Next, for the decision between random and fixed-effect ML estimation, As seen in Table 10 and Table 9, the p-value of the Wald test for the overall significance of the model and the LR test for the REME model is 0.0000. Thus, the null of all coefficients of the explanatory variables is zero and can be rejected at the 5% level of significance. That is, the explanatory variables included in the model jointly explain a significant portion of the variation in the dependent variable; hence, the overall significance of the model is achieved at the 5% level of significance.

Besides, from the LR test result, the null of the random mixed-effect effect model is better than the fixed effect model and can be rejected at the 5% level of significance, implying that the REME model, by accounting for the dependence of the observations clustered within HHs, performs better than the linear mixed-effect model. This shows that it would be a mistake to simply use the linear mixed effect result estimated by considering traditional random variables independent of adults.

As a result, the within-HHs fixed mixed effect model estimate provides theoretically sound interpretations for a larger population context, which aids in understanding adult Ethiopian

individuals' IFB usage. analysis of IFB use by adults in the same family is dependent on other adults within the same HH while independent or randomly varies with other adults across HHs. This method also helps to account for differences between individuals, as the researchers included adults in the same HHs as a fixed effect. Therefore, the study used the results of the within-household variance-controlled REME model (column 5) for further interpretations and discussions.

Results Interpretation and Discussions

Digital and financial literacy influences on IFB service use: As seen in Table 9, Column 5, the P-value of the coefficients of DFL and FL scores is less than 0.05. A p-value less than 0.05 typically indicates that the effect is statistically significant, suggesting that both the DFL and FL scores have a meaningful impact on the likelihood of using Islamic banking services. Particularly, the positive coefficients of 0.225 of the DFL score in the model are statistically significantly different from zero at the $p < 0.001$ level of significance. This test result indicates a one-unit increase in adult skills in DFL will lead to 0.255 points on mean increases in IFB use. Also, the positive coefficient of 0.0441 of the FL-score indicates a one-unit increase in FL_scores improves adults' IFB Financial inclusivity by 0.0441 points on average. This finding is also statistically significant ($p < 0.001$). This suggests that both DFL and FL scores are good predictors of whether individuals will use the IFB service or not. This finding is confirmed by Choung, Y., et al. (2023); Prete, A. (2021); and Ozili, P. K. (2021).

Financial literacy is conceptually multidimensional. As can be seen from Table 8, the results revealed that IFB service usage is positively influenced by adult knowledge and behavior sub-dimensions of financial literacy. It suggests that the knowledge score's beta coefficient is 0.0359, meaning that an increase in adult financial literacy of one unit is linked to an average rise in the use of Shariah-compliant banking services of 0.0359 points.

The effect of adult financial attitudes is negative on the use of IFB services. Bunyamin & Mutlu (2017) argued that this negative perception among some adults results from the claim that IFB products are more expensive compared to conventional. However, the finding is statistically insignificant at a 5% p-value, except for financial knowledge. The research results confirm that those who are financially literate are more likely to understand financial concepts, products, and services. According to Astuti (2023), this competence enables them to make more informed decisions, compare available options, and select appropriate financial products that suit their needs.

The likelihood of adults using formal financial institutions and profiting from financial inclusion therefore rises. Consider that actual importance does not always follow from statistical significance. Previous research, like Zulkhibri, M. (2016), Khan, F., et al. (2022), and Shinkafi, A., et al. (2019), claimed that financial inclusion is sensitive to individual proficiency. The availability of Islamic financial services and products does not guarantee a rise in financial inclusion unless people recognize the importance of these products in handling their finances.

The influence of women on IFB use: Table 9, Column 5, Results reveal that the positive coefficient and significant ($p < 0.05$) effect of females on IFB use indicate that women have a higher likelihood of using IFB compared to men. Although gender bias due to within-household observational correlation is controlled in the fixed effect REML results, This study result refutes prior claims that being female created a significant statistical difference in acceptance of IFB financial services. The same result for Indonesia, Bangladesh, Turkey, and Uganda was confirmed by Datta, P. B., & Manjula, R. (2019), Naceur et al. (2015), Baele et al. (2014), and Mohieldin, M., et al. (2011). These prior studies argue that the combination of principles and values—religious preferences, experience of financial exclusion, and socioeconomic factors—leads to a positive relationship between being a woman, unemployed, living in a rural area, and using shariah-compliant financing services. However, according to Abedifar et al. (2016) and (2013), gender differences are mixed, as

the findings are not conclusive regarding the positive or negative effects of gender on shariah-compliant banking and finance use.

Age influences on IFB use: The negative and positive coefficients of age and squared age, respectively, indicate that age has a non-linear causal effect on IFB finance use among adults in Ethiopia. That is, up to some levels of age, an increase in age increases the use of IFB services by adults. This research result shows that IFB's services are more used by older adults than young adults. The same result was revealed by Khmous, D., and Besim, M. (2020), who found that being male and older positively affects Islamic financial inclusion in MENA countries. In this research, on the other hand, age differences do not reveal a significant influence on the inclusive use of IFB by adults in Ethiopia at a 5% level of significance.

Education and mobile phone ownership: Replication of well-established results, educational attainment, and owning a mobile phone positively affect the probability of using IFB services, indicating common patterns across different contexts with prior results of Ali, J., & Ghildiyal, A. (2023), Kurunkatil, U. (2019), Fungáčová & Weill (2015), and Demirgüç-Kunt et al. (2018). However, Khmous, D., & Besim, M. (2020) and Baele et al. (2014) claim that the IFB service preference by these demographic groups is due to the high quality of education, the absence of interest, and the availability of business start-up support from the IFB financial institutions. Additionally, the results of this study contrast with those of Albaity, M., & Rahman, M. (2019) and Ahmad, A. E. M. K., & Al-Zu'bi, H. A. (2011), who contend that the lack of digital skills associated with owning a mobile phone does not positively influence the usage of IFB services. They claim adult clients' trust and use of Shariah-compliant financial services might be adversely affected by data security and privacy concerns, such as the possibility of data theft.

Shock and Financial Capabilities: Table 9 also shows a positive correlation between an individual's financial capabilities and the shock resilience effect on IFB use. The ability to save 600 Birr at least once a year is the average measure of financial ability and a proxy

for income. which implies lower-income adults are positively related to the likelihood of utilizing IFB. Similarly, it has been found that individuals who are shocked or concerned about their ability to pay for unforeseen costs are more likely than their counterparts to use IFB services. However, at a 5% significance level, neither financial capacity nor shock resilience showed any clear variance in the use of IFB by individuals living in Ethiopia.

Informal (Equb) saving: Adults who prefer to save money in the informal financial sector have a positive and significant effect on the use of formal financial services through IFBs. Our modeling result indicates informal saving (EQUB) has a positive and statistically significant (at a $p < 0.001$) influence on IFB Financial inclusion. The result indicates a one-unit increase in savings for Equb will increase the likelihood of using formal interest-free financial services by 0.0374 on average. The same result was revealed in West African Economic and Monetary Union (WAEMU) countries by Coulibaly, M., & Sirpé, G. (2023), and also by Abdesamed, K., & Wahab, K. (2015), who asserted that saving informally positively affects individuals' behavior to save formally.

Distance from FFI, Rural Residents, and Unemployment: From the above Table 9, individuals who live far from FFI, being rural residents and unemployed adults, are less likely to use IFB financial services than their counterparts. This insight is consistent with prior studies by Lyons, A., et al. (2020), Giday, H. G. (2023), and Desalegn & Yemataw (2017). On the flip side, the impact of FinTech's game-changing function, which is not constrained by physical accessibility, is promoting adult financial inclusion regardless of residential location or proximity to FFI. For example, according to Ali, A. S. (2020), some microfinance institutions in rural areas, such as Somali, Harar, and Dire Dawa microfinance S.S. and Oromia Credit Saving Sharing Company (OCSSCO), provide savings and credit services based on Shariah principles, thereby increasing the financial inclusion of rural residents and unemployed adults.

Adult religious affiliation on IFB uses: The use of IFB is also influenced by adult religious membership. Protestant Christians and Catholics displayed a negative correlation between

using IFB services relative to the EOTC Christian religion. Muslim adults and other religions (Wakefeta and Pagan) exhibited favorable sentiments about IFB inclusivity. In this sense, compared to their orthodox Christian counterparts, Muslim adults have a much higher probability (at a 1% level of significance) of utilizing IFB services. According to prior support by Abedifar et al. (2016), Naceur et al. (2015), and Demirgüç-Kunt et al. (2015) and (2013), shariah-compliant banking and finance provide an alternative for individuals who prefer interest-free financial services due to religious beliefs, increasing the financial inclusivity of adult Muslims. However, it is debatable whether the policy (Hailu, S., et al., 2019) resulting from NBE's 2019 launch of the IFB service as part of the 2013 national financial inclusion reform has enhanced adult Muslims' financial inclusion in Ethiopian financial institutions.

Regional Geographical Location Influence on IFB Use: The regional variation in IFB use in Ethiopia is also revealed by the positive and statistically significant coefficients of Oromia and Harar at 1% and 5% significance levels, respectively. Accordingly, compared to adults living in Addis Ababa, the capital city, adults living in Oromia and Harari regional states of Ethiopia have shown a strong likelihood of using the IFB service. A similar positive relationship was revealed between adults living in Afar, Somalia, SNNP, Dire Dawa, and IFB services. While being an adult from Amhara and Tigray regional states has negatively related to IFB service using keeping other things constant, the latter result is insignificant at 5%.

Conclusion and Implications

In this study, the mixed effect model was used, which accounts for the nested structure of the data by including both fixed effects, deviations, and random effects across households. The modeling robustness test confirmed the trustworthiness and validity of this modeling approach for an unbiased conclusion. To begin, the findings revealed that both digital and financial literacy among Ethiopian adults have significant positive influences on their ability to accept IFB financial services. As per the study, higher levels of these literacies

are associated with more informed adult financial decisions, which in turn enhance adult IFB financial inclusivity. Secondly, the survey result uncovers that women are more likely to use shariah-compliant financial services (IFB) than men, and similarly, shocked adults and lower-income adults are more likely to use this alternative financing. This makes IFB services and products a more important model for gender, lower income groups, adult financial resiliency, and well-being. Thirdly, the study found that informal saving for EQUB, higher educational attainment, and owning a mobile phone positively affect the probability of using IFB services. Specifically, mobilizing savings from informal institutions, e.g., institutionalizing digital ROsca (EQUB), has a beneficial influence on IFB financial inclusion. Fourthly, the data highlights rural adults, the unemployed, and those living far from FFI hubs are less likely to use Shariah-compliant financial services. This insight, consistent with prior studies, confirms persistent adult financial exclusivity. Finally, the study concludes significant regional and religious affiliation disparities in using IFB services in Ethiopia.

The following policy recommendations were forwarded to various government, federal, and regional organizations and individuals, such as the National Bank of Ethiopia (NBE), the Ministry of Innovation and Technology (MinT), the Ministry of Education, NGOs, public and private financial institutions, and fintech companies that are working to promote digital transformation and financial inclusion in Ethiopia.

- strengthening and developing comprehensive digital and financial literacy programs aligned with the initiatives that focus on promoting an optimal, digital, and inclusive financial system among adults, especially women, rural, and lower-income groups, This can involve creating national plans, integrating digital financial education into school curricula, training, and educational procedure reforms, conducting awareness campaigns on IFB education (for educators and institutions), and developing DL training programs and modules. Regulators, fintech companies, IFB service-providing financial institutions, and other stakeholders could collaborate through public-private partnerships to promote financial inclusion. This could also

involve encouraging value-based financing, knowledge-sharing, and capacity-building programs, and facilitating learning experiences and adaptations. Tailoring the content and delivery of such education to the diverse socioeconomic and demographic contexts of adults is also crucial.

- prioritize investments in digital infrastructure to improve internet connectivity and mobile network coverage, particularly in rural and underserved areas. This could be done by fostering public-private partnerships to accelerate infrastructure development, ensuring that affordable technology solutions, such as low-cost smartphones, are accessible to low-income individuals. The Digital Ethiopia strategy emphasizes the need for such collaborations to enhance digital access and inclusion.
- promote gender inclusivity in financial services, including financial institutions and government bodies. Required to be encouraged to innovate and promote financial products aimed specifically at women, recognizing their higher engagement with IFB services. This will be possible by creating awareness campaigns and supporting networks that empower women to utilize financial services and enhance their financial decision-making capabilities. This could also include savings accounts with IFB principles or micro-financing options that cater to women entrepreneurs.
- establish a supportive regulatory framework with the National Bank of Ethiopia (NBE) and other regulatory bodies. It is advised to create a supportive, transparent, and flexible regulatory environment that encourages innovation in digital financial services and IFB human resources developments to serve users and strengthen institutions. This could include educational and training procedure reforms to facilitate the entry of IFB educational and training institutions and enabling licensing processes. It recommends policymakers use the IFB model for future inequality reduction and regular monitoring of policies and regulatory frameworks to maximize benefits. This aligns with the Homegrown Economic Reform Agenda, which aims to liberalize key sectors and promote inclusivity.

- Foster Community-Based Financial Solutions: Support the integration of informal savings groups, such as EQUB, into the formal financial system. Provide training and resources to these adults, helping them transition to using formal banking services and improve their financial well-being. This approach can leverage existing community trust and networks to promote IFB services.
- Address Regional Disparities in Adult Financial Inclusion: Develop region-specific strategies that consider local socioeconomic conditions and cultural factors affecting financial behavior. Policymakers can implement targeted outreach programs in rural and remote areas to raise awareness of IFB services. In this case, local governments can integrate their plans with the homegrown economic reform agenda to drive digital transformation and financial inclusion.

Further Research and Limitations:

The study on IFB service-linked digital financial literacy for financial inclusion is too broad and requires deep micro-level studies for specific social demographic groups. It also needs a national, updated survey to reassess the digital financial literacy gap. The study's limitations include the absence of supply-side data and more years of baseline data.

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