

The Effect of Digital Financial Services on Financial Inclusion in Ethiopia

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The digital economy is rapidly expanding globally, with the potential to significantly boost socio-economic development, particularly in developing countries. The banking industry is significantly investing on introducing digital financial services especially in developing countries like Ethiopia ultimately to achieve financial inclusion goals. Hence, this study was aimed to investigate the effect of digital financial services (DFS) for financial inclusion in Ethiopia. For this purpose, secondary data was collected from the National Bank of Ethiopia, the study specifically focused on seventeen commercial banks (panel units) from the year 2014/15 to 2023/24. The random effect model was applied to estimate the effect of explanatory variables on the variable of interest based on Hausman test results and after testing all possible assumptions of the model. Accordingly, the finding revealed that Mobile banking, ATMs, POS terminals, and Mobile Wallet Banking all has a positive and significant effect on the number of financial accounts in Ethiopia. These services are driving financial inclusion by increasing access to banking services and facilitating the opening of accounts. Internet banking appears to have a negative impact on the number of accounts, which might reflect limited access to or use of internet banking in Ethiopia, possibly due to issues like connectivity or low digital literacy. The authors propose that enhancing the adoption of digital financial services (DFS) in both rural and urban areas could play a crucial role in advancing financial inclusion. They argue that such an increase would directly support the financial inclusion strategies of policymakers and banking practitioners. By improving access to digital financial tools, individuals in these regions often underserved by traditional banking systems could be integrated into the formal financial sector.

Keywords: digital financial services, financial inclusion, banking sector, panel data analysis, Ethiopia

Introduction

Financial inclusion is essential for ensuring that individuals and businesses can access affordable financial products and services. Providing inclusive financial services to unbanked communities has become a global priority, especially in developing countries. Access to finance is a key driver of economic development and social well-being. Financial institutions play a crucial role in making these services available to the wider society (Abor et al., 2019). The banking sector is a significant contributor to the financial inclusion strategies of many countries (Rafique et al., 2018). Similarly, microfinance institutions are instrumental in delivering financial services, particularly to rural and urban households, as well as small and medium-sized enterprises (SMEs) (Mushtaq, &

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Bruneau, 2019). Despite progress, inclusive financing remains a critical issue in developing countries and continues to be a central goal for global organizations, including the United Nations (Senyo et al., 2022).

Financial inclusion is considered as one of the key strategies that international organizations like World Bank, IMF and UN emphasizing for the social welfare in developing countries like Africa. According to the United Nations (UN) “agenda 2030” Sustainable Development Goal (SDG), ensuring financial inclusion especially in the low-income countries expected to improve livelihood and economic growth as different authors reported (Kling et al., 2020). Studies shows that financial inclusion helps for ensuring the sustainable financial service development (Le et al; 2019), Poverty reduction (Mushtaq, & Bruneau; 2019), firm’s sales growth (Lee et al., 2019). Similarly, studies confirms that financial inclusion helps for ensuring gender equality and economic growth (Asongu et al., 2020).

Financial inclusion in Africa remained low and needs strategic intervention besides the contribution of advancement in information technologies. The goal of financial inclusion has faced many challenges in Africa as indicated by some authors like financial illiteracy and poor financial infrastructure (Grohmann et al., 2018), demographic factors (age, gender, education and income level) (Zins, & Weill, 2016). According to the Global Findex report the number of mobile and internet based digital finance users are increased from 67% to 76% globally and specifically in developing countries from 57% to 70%. This might imply that financial technologies like internet banking, mobile banking and other user manageable financial service technologies positively contributing for financial inclusion (Demirguc-Kunt et al., 2017).

Financial technology (FinTech) is new innovations of financial products that deliver financial services to users in more convenient and affordable prices. Its’ aim is to reach a broader range of customers, in a more efficient, cheaper and customer-friendly way than traditional bricks- and mortar financial services (Wamba et al., 2021). The business model of Fintech takes different approaches; peer to peer lending, mobile payment, crowd funding, micro-finance, block-chain and crypto-currencies in developed countries (Liu et al., 2020). The FinTech investment is globally increased from USD 19.9 billion in 2014 to USD 39.4 billion in 2017 and rise to USD 41.7 billion in 2018 according to Fintech Global. Many reports indicated that Fintech is a game changer in financial inclusion strategies of countries. It have been witnessed that fintech business models help to allow the under and unbanked society to have access to financial services at affordable price in more simple way.

According to the 2020 universal financial access (UFA2020) agenda of World Bank, Ethiopia was one of among the 25 priority countries to achieve the goal of helping adults “be able to have access to a transaction account or an electronic instrument to store money, send payments and receive deposits as a basic building block to manage their financial lives”. As it was reported by global Findex, the number of adults with bank accounts increased from 22% in 2014 to 35% in 2017 while 26% of adults save at financial institutions in the same year. Similarly, the number of adults borrowing from financial institutions increased from 7% in 2014 to 11% in 2017. However, inclusive financial service in Ethiopia remains low compared to other African counties. For example, in Kenya 82% of adults have an account, while in Rwanda, account ownership stands at 50%. Similarly, only 26% saved formally at financial institutions and only 11% borrowed from financial institutions, which shows majority of Ethiopians relays on informal financial system. The innovation of new financial technologies (Fintech) recognized as a “game changer” tool in accelerating the financial inclusion. However, the adoption and expansion of financial technology is not diffused well in Ethiopia (Jerene, & Sharma, 2020). Almost all (99%) adults pay utility bills with cash in Ethiopia, compared to 12% of people in Kenya and 59% in the region as a whole. The Ethiopian business transaction is more cash dependent and evidences sows that only 0.3% of adults had a mobile

money account in the same year, according to Findex. About 13 million people with a mobile phone are unbanked. Similarly, the practice of financial service is still limited to the urban part of the country and needs much efforts and strategies on financial inclusion to the unbanked community (Dinku, 2021).

Many causes for the limited inclusive finance were reported by authors. According to the World Bank report; insufficient funds, distance from financial institutions, absence of document requirements and financial costs respectively as majority agrees. Beside those barriers researchers were also reported individual as well as institutional factors (Kling et al., 2020). However, it is believed that the advancement of financial technology significantly solving the barriers like distance, document requirements. For enhancing financial inclusion strategy Ethiopia was established national financial inclusion council and financial inclusion secretariat at National Bank level. According to the financial inclusion strategy of National Bank of Ethiopia (NBE); it was planned by 2020 the number of adult account holders 60%, 40% of adults save at formal financial institutions, 40% adults to be use electronic financial system (NBE, 2017). Following the political reform, Ethiopia is under the implementation phase of digital transformation for it's the next ten years development plan (2020-2030). Following the digital Ethiopia strategy NBE revised its digital payment directives and fintech companies operation legal frameworks. Among others; the mobile money technologies; recently TeleBirr was launched by the state-owned operator Ethio Telecom in May 2021. As well as 21.14 million users (and rising) it boasts that TeleBirr-based transactions have reached 25.67 billion Ethiopian birr (just under US\$492 million) integrating with 13 banks to transfer money from the banks to the platform. Hence, it is believed that policy reform might help to improve the financial inclusion strategies.

Though many authors have been studied about the advancement and contribution of fintech for economic growth (Li, 2018), less attention has been given for investigating its effect on financial inclusion especially from developing countries perspective. More over Ethiopia is currently under aggressive implementation of digital transformation plan for ten years. Therefore, the outcome of this study would contribute to the stock knowledge in confirming the role of financial technologies for ensuring inclusive financial services in developing countries with special focus on Ethiopia. Similarly, this study would shade a light to managers of financial institutions how to synergistically work on expanding the digital financial services expansion in order to facilitate inclusive finance for all. Hence, the objective of this study was to investigate the effect of digital financial services for ensuring financial inclusion in Ethiopia, using formal econometric methods the panel data analysis. The remainder of the paper is organized as follows. Section 3 presents a literature review. Section 4 presents a brief description of the data and statistical methodology. Section 5 reports the empirical findings and discusses the results, and, finally, Section 6 concludes and discusses policy implications.

Overview of Historical Development on DFS and Financial Inclusions in Ethiopia

Ethiopia is the second highest populous nation in Africa with only 35% banked population compared to 55% sub-Saharan African countries (World Bank, 2023). The number of deposit accounts across all banks has climbed to 129.52 million in Ethiopia in 2023 owing to the notable growth in the banking sector, according to National Bank of Ethiopia (NBE, 2023). Historically, banks have offered DFS in Ethiopia to enable their customers to access their regular bank accounts (usually urban). The services have included debit cards that can be used at ATMs and point-of-sale (POS) devices, and later mobile banking channels for customers to check their balances.

In 2012, the NBE issued the Licensing and Supervision of the Business of Financial Institutions Directive, which authorized licensed financial institutions in Ethiopia to offer mobile banking and use agent networks to

expand their reach. Under a bank-led model, banks and microfinance institutions (MFIs) were authorized to partner with technology providers to develop and deliver the service. This regulatory reform led to the launch of Ethiopia's first mobile banking service, M-BIRR, in 2015. Collaboration between five MFIs and Ethio Telecom, M-BIRR was successful in building the technology infrastructure needed to support mobile banking and digitalizing G2P payments. Hello Cash is another mobile banking service that was launched by Lion Bank, the Cooperative Bank of Oromia and Somali Microfinance Bank around the same time. It was primarily used by the government to digitize social protection payments under the flagship Productive Safety Net Programme (PNSP). A key challenge in this early phase was that MFIs operated in a nascent ecosystem and lacked sufficient capacity to scale. Banks also offered mobile banking services, but focused on low-volume, high-value products, such as lending in urban areas. Mobile banking services were peripheral to banks' business models and suffered from limited investment and resources.

In 2020, low rates of financial inclusion and mobile banking uptake prompted the Ethiopian government to shift from a bank-led mobile money model to a hybrid model. The introduction of the Payment Instrument Issuers Directive, the Payment System Operator Directive and the Use of Agents Directive allowed foreign investment in the telecoms sector for the first time and permitted non- financial institutions to offer mobile money services. It also supported the use of a broader range of channels for the delivery of digital financial services, such as POS, ATMs and payment gateways.

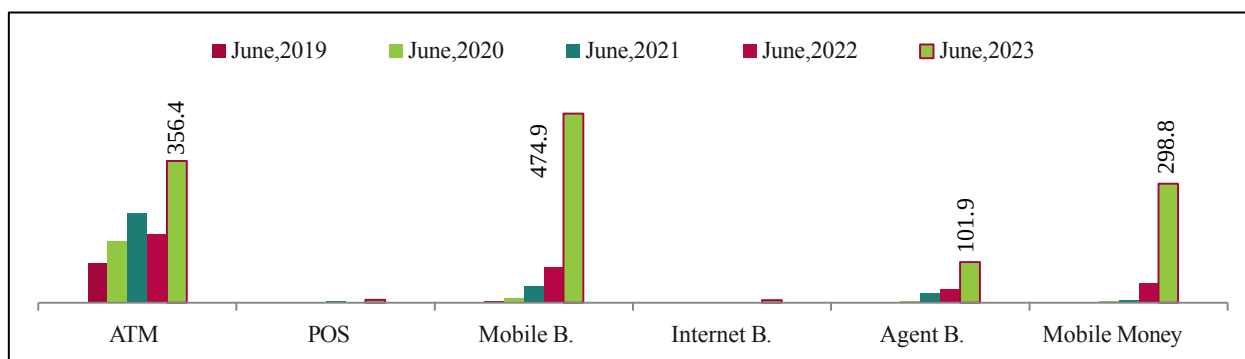


Figure 1. Trends of financial transaction volume per digital channel (in Trillion) in Ethiopia.

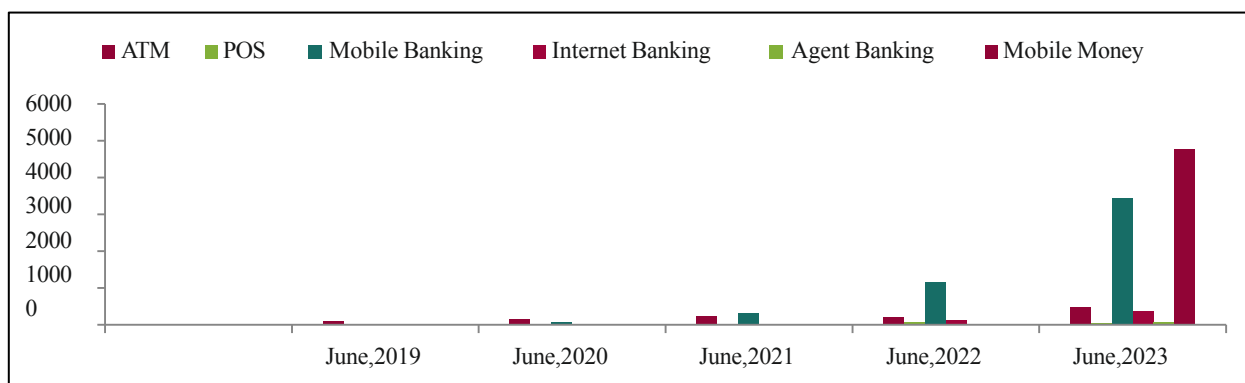


Figure 2. Trends of financial transaction (value in Billion Birr) in Ethiopia.

Figure1, Rapid growth in mobile banking and mobile money there is a clear upward trend in mobile- based banking, with mobile banking transactions rising significantly each year, particularly in 2022 and 2023. Mobile

money also expanded greatly, especially in 2023, ATM remains dominant but growth slows. While ATM transactions are still a significant portion of total transaction volumes, they showed a slower growth rate compared to digital banking solutions. ATM volume saw a steady increase, but the rate of increase decreased compared to mobile channels. Both agent banking and internet banking have seen considerable growth, indicating an increasing trend of financial services reaching the population through a mix of physical and digital channels.

Figure 2, in 2023, mobile banking became the dominant channel, reaching 3,442.58 billion Birr, reflecting an ongoing shift toward mobile and digital solutions. Mobile wallet also grew sharply, surpassing 4,776.77 billion Birr, which is far larger than all other categories. ATM transactions grew to 478.32 billion Birr, though it remained much smaller than mobile channels. POS transactions slightly decreased but remained a considerable value at 40.84 billion Birr and Agent banking saw significant growth, reaching 76.54 billion Birr, and internet banking grew to 358.14 billion Birr.

Literature Review

Theoretical Review

Theories of Financial Inclusion. Regarding the beneficiaries of financial inclusion Ozili (2020b) stated four theories: public good theory, dissatisfaction theory, vulnerable group theory, and system theory. Accordingly, the public good theory stated that financial service has to be available to every citizen as a public good and it benefits the people at large than to specific group while dissatisfaction theory states that financial inclusion addresses those unsatisfied groups of individuals from the conventional financial services. According to the author, the vulnerable theory states the financial inclusion programs in a country should be targeted to the vulnerable members of society who suffer the most from economic hardship and crises, such as poor people, young people, women, and elderly people. The theory argues that vulnerable people are often the most affected by financial crises and economic recession, therefore, it makes sense to bring these vulnerable people into the formal financial sector. The system theory also states that financial inclusion more helps the sub system (such as the economic, social and financial systems) of the economy rather than the whole system. However, in this paper we gave more emphasis about the delivery of financial inclusion rather than the beneficiaries. Therefore, in the following section we dealt about financial inclusion delivery theories.

As Ozili (2020b) explains the special agent theory of financial inclusion argues that formal financial services should be delivered to the excluded population by special agents than the government as public goods. Often, the provision of formal financial services to unbanked adults can be difficult due to the nature of remote communities, its people or the geography. For this reason, there is need to employ the services of specialized agents to deliver formal financial services to members of excluded communities. According to this theory the special agent should have quality skills and other experiences regarding the financial services and the target community. The special agent is competent, highly skilled and has superior ability to bring the excluded population into the formal financial sector so that they can have access to formal financial services. Under this theory, there is an agent-principal relationship with different level government both national and international. Special agents may comprise, financial institutions and technological companies. This theory was originally based on the agency theory (Eisenhardt, 1989).

According to this theory financial inclusion is a public responsibility which the government owes its citizens, and the citizens expect the government to deliver formal financial services to citizens (Ozili, 2020b). This theory

argues that formal financial services should be delivered to all citizens by the government through public institutions. Public service theory is similar to the public goods theory, which emphasizes the government should deliver financial service to all its citizens (Oakland, 1987). The author claims three advantages of this theory; firstly, this theory points out government is responsible for delivering financial services; secondly, the theory suggests also the government controls the whole system of resources including socioeconomic structure and financial system. Thirdly, the public service theory enhances the public confidence.

Financial Inclusion and Financial Technology. Financial inclusion can be defined that the effort of making basic financial services available to everyone through simplifying the barriers. According to the World Bank definition financial inclusion means “individuals and businesses have access to useful and affordable financial products and services that meet their needs; transactions, payments, savings, credit and insurance delivered in a responsible and sustainable way” (Demirguc-Kunt et al., 2017). According to Yoshino, and Peter Morgan (2018) financial inclusion is defined as “the degree of access of households and firms, especially poorer households and small and medium-sized enterprises (SMEs), to financial services”. As most authors agree financial inclusion is about facilitating access to financial service for unprivileged community. Providing financial service for unbanked society believed that it minimizes economic inequalities (Kling et al., 2020). Similarly, Demirguc-Kunt et al. (2017) defined financial inclusion as a means of providing financial service for all adults in a safe and efficient manner. Authors claimed that financial service can be provided either by conventional banking system or through advanced financial technologies (FinTech) for ensuring financial inclusion.

Financial technologies (FinTech) include the non-conventional banking services through startup entrepreneurial innovative technologies and banking digital financial services too. As authors agree that financial technologies like mobile money significantly contributes for financial inclusion in developing countries (Mathieu, & Kakinaka, 2020). The digital banking services using internet banking, mobile banking, and ATM services were found positively increasing the financial inclusion strategy (Fernandes et al., 2020). Similarly, a study in Ghana confirmed that the new FinTech Eco system playing a significant role for ensuring financial inclusion (Senyo et al., 2022). Since the financial technologies can be easily operated by using internet and text messages through telecom infrastructure, society living far from the traditional bank branches can get access to financial services at low cost. Though there are infrastructural challenges in developing countries, still the digital financial services harnessing the contribution of financial inclusion strategies (Wonglimpiyarat, 2018). In Africa Fintech was appreciated even for ensuring gender equality (Senyo et al., 2022), income equality (Kling et al., 2020). Studies in Africa also confessed that the advancement of digital banking services like mobile banking, positively contributing for access to finance in the rural community (Fernandes et al., 2020).

Review of Empirical Studies

In terms of the study of the determinants of financial inclusion, Olaniyi and Adeoye (2017) examined a panel data using the number of clients with deposit accounts per 1,000 adults as a proxy for financial inclusion, with the determinants of financial inclusion including, amongst others, the number of internet users per 100 people and the number of institutions providing safe internet. Their results showed that these indicators have a significant impact on financial inclusion and concluded that internet access and coverage are key factors for achieving an economy based on digital financial services and financial inclusion, especially for populations without physical access to bank branches.

Similarly, Le Roux (2018) also studied the impact of internet access as one of the determinants of financial

inclusion and concluded that increased internet connectivity has a significant and positive impact on financial inclusion.

Gebregziabher and Makina (2015) studied the determinants of financial inclusion in 27 African countries for the period of 2004 to 2013 and found a positive impact for mobile infrastructure and the use of mobile phones on financial inclusion. Adekunle (2017), in turn, analyzed the determinants of financial inclusion in sub-Saharan Africa from 2004 to 2015. These authors considered as a proxy for financial inclusion the volume of credit and deposits per thousand adults, and as explanatory variables, a set of bank variables including the number of ATMs, POSs and bank branches. Socioeconomic variables included the number of individuals with access to a mobile phone service. The authors found that the number of ATMs, internet providers, and mobile banking services, all have a significant positive effect on financial inclusion, in sub-Saharan Africa.

Other studies strictly analysed the relationship and impact that digital financial services have on financial inclusion. Were (2017) measured financial inclusion as being the volume of financial savings, and studied its dependence on two sets of indicators: firstly, the access or use of mobile financial services by individuals, and secondly, a group of control variables, such as education, gender, age, location, and income. These authors concluded that the impact of digital financial services on savings is positive and highly significant, showing that users of these mobile financial services are more likely to save than those without access to them, confirming the role of mobile financial services in mobilizing savings, as they reduce distance and transaction costs.

Agyekum (2016) studied the effects of digital financial services on the financial inclusion of Ghana's economy. They analysed the impact of information and communication and technology (ICT) and concluded that mobile subscription has a significant and positive impact on financial inclusion, which suggests that the adoption of mobile financial services will favorably affect the financial sector.

Anand (2017) studied the effects of technology diffusion on financial inclusion and economic growth. The authors considered an ICT development index developed by the United Nations International Telecommunications Union (ITU), calculated for 175 countries, which includes indicators such as mobile and fixed network penetration, internet usage, and technology import. Their study also uses other digital financial services indicators, such as the number of ATMs. These authors concluded that the impact of internet users on the number of deposit accounts is positive and significant. They found that indicators such as the number of individuals with access to ATMs, the volume of credit to the private sector, and the number of bank branches also have a positive and significant impact on the number of bank accounts.

Kithinji (2017) studied the case of Kenya, from 2012 to 2016. His analytical model consisted of a regression where the dependent variable was the sum of the number of bank and mobile accounts available from electronic money institutions. Independent variables included the value of the investment in e-money, online banking, bank branches, and ATMs. The author concluded that digital finance strategies have a statistically significant effect on financial inclusion and that the most significant digital finance strategy is mobile banking, followed by ATMs, banking agents, and online banking.

Harelimana (2020) analysed data from a sample of 253 individual questionnaires, using as dependent variables indicators the electronic payment system, such as the number of bankcards, mobile banking, internet banking, and online remittances. This study concluded that electronic payments are critical for improving financial performance.

Methodology and Data Sources

Data Sources and Variable Description

The data used in this study to assess the effect of digital financial services on financial inclusion was obtained from the National Bank of Ethiopia, covering the period from 2014/15 to 2023/24. Ethiopia now has 32 commercial banks, one government-owned bank, and one development bank. Out of Ethiopia's 32 commercial banks, the study focused on seventeen banks, selected based on their years of establishment and experience. The data were balanced panel data, which captured both cross-sectional and time-series behaviors simultaneously. Digital Financial services considered in this study includes, internet banking, mobile banking, agent banking, POS machine, and ATM. Financial inclusion was measured using the number of deposit account as many authors suggests (Nguyen, 2020). Thus, the dependent variable of the study financial inclusion (was proxied by number of deposit accounts) is a continuous variable.

To studying the role of digital financial service on financial inclusion and their hypothetical relationship development is presented as follows:

Mobile Banking and Financial Inclusions

As money agrees that the expansion of mobile technology is significantly helping for accessing the traditional financial services in the bank. A financial technology like mobile money significantly contributes for financial inclusion in developing countries (Mathieu, & Kakinaka, 2020). Not only mobile banking but also the other financial technologies like internet banking, mobile banking, and ATM services were found positively increasing the financial inclusion strategy (Fernandes et al., 2020). However, according to Kim (2022) mobile money particularly enabling women in Nairobi to access financial service for instant remittance and payment services, and has offered a means of storing money safely. In line to this others researchers were also confirmed that mobile money playing a positive role in financial inclusion (Shen et al., 2020). Therefore, in this study it was hypothesized as follows:

H1: Mobile banking has positive significant effect on the financial inclusion.

Automated Teller Machine and Financial Inclusion

According to Ardic et al. (2011) growth in the retail network varies across regions and income groups. Low-income countries show the highest rates of growth in the number of bank branches, ATMs, and POS terminals, which is another sign of improved access to financial services. Accordingly, Africa, South Asia, and the Middle East, the regions with the lowest levels of retail network outreach, show higher rates of growth in the number of bank branches and ATMs. ATM has allowed consumers who previously did not have access to financial service to setup bank account. According to Gordon Colin (2018) Indian government acknowledges ATMs are the first step to increase financial inclusion in India. As the author mentioned, India has just 183 ATMs per million according to data from global ATM market and forecast to 2022. With the global average at 448 ATMs per million this clearly highlight that the ATMs has a very important role to play in terms of financial inclusion in the future. Thus, it is hypothesized as follows:

H2: Automated teller machine (ATM) has positive significant effect on the financial inclusion.

Point of Sale Terminal (POS) and Financial Inclusion

According to Umar (2019) effective financial inclusion provides various alternative means of electronic payments, such as online payment, credit transfer, debit cards and POS, which enable customers to make payment when they have no cash in hand. Consequently, this would contribute to the reduction of bad debts. Accordingly, financial inclusion improves the record keeping of the businesses using POS. Among key payment systems and

platforms for promoting financial inclusion are inter bank systems for electronic retail fund transfers, including automated clearing houses (ACH) and electronic money systems (EMS), platforms for processing payment cards (also known as card switches), access and service point networks, such as points of sale (POS) (CEMLA, 2016). Similarly, Schwabe (2013) reported that that Point-of-sale terminals (POS) and ATM's, has positive effect on account penetration, opening of new account and its attributed to market structure.

H3: Point of sale terminal (POS) has positive significant effect on the financial inclusion.

Internet Banking and Financial Inclusion

The advancement of information technology especially internet significantly contributing advancement of electronic banking (Dha, 2015). Internet banking allows bank customers to access the financial services from anywhere. As many authors agrees that the revolution of fintech is directly relates with the advancement of internet service (Wamba et al., 2021). Therefore, it was hypothesis as follows:

H4: Internet banking has positive significant effect on the financial inclusion.

Agent Banking and Financial Inclusion

Agents are trusted local retailers who are helping the local community to get financial services without visiting the bank branches. According to Cull et al. (2018) they are lower-cost alternatives to bank branches that enable customers to more conveniently make deposits, withdrawals, money transfers, and payments on loans. The authors were confirmed in their study in Democratic of Congo; agent banking was significantly contributing for financial inclusion among urban poor people. It is highly trusted that agent banking helps the poor economic groups to have access to financial services. In this regard Bizah et al. (2017) reported that agent banking regarded as a key driver of financial inclusion in poor communities. Therefore, it was hypothesized as follow:

H5: Agent banking has positive significant effect on the financial inclusion.

Mobile Wallet Banking and Financial Inclusion

Mobile wallet banking and financial inclusion is symbiotic. As mobile wallet technology continues to evolve, it holds the potential to create more inclusive financial ecosystems by breaking down the barriers of geography, affordability, and access to services. With lower transaction costs, increased digital literacy, and an expanded range of financial products, mobile wallets can significantly advance financial inclusion for those who have been historically excluded from formal banking systems.

H6: Mobile wallet banking has positive significant effect on the financial inclusion.

Model Description and Specification

The panel data estimation method has been used to test the statistical significance of the various independent variables on dependent variable, because the dataset contains observations on multiple entities (banks), where each entity is observed at multiple time periods.

The general notation for the basic panel data model is:

$$Y_{it} = X'_{it}\beta + v_{it} \quad (1)$$

where, a double subscripts i, t refer to cases or the unit (e.g. individual, household, firm, state, entity...) & time period (year), respectively; $i = 1, \dots, N$ and $t = 1, \dots, T$; N- number of observations and T- number of time periods/observations for each individual(each time is referred to as a "wave"), = vector of covariates, V_{it} = Composite error term ($V_{it} = \alpha_i + u_{it}$), the most important part of the analysis, where α_i = unobserved unit-specific error or (unobserved heterogeneity), which is unobserved fixed effect or time-invariant and correlated with X_{it}

(fixed effect model), but if uncorrelated (Random effect model) & specific to each individual, and, u_{it} = idiosyncratic error which varies over individuals and time (the usual error term) and it should fulfill the assumptions for standard OLS error terms.

Accordingly, the empirical model of the study is developed as:

$$FI_{it} = \beta_0 + \beta_1 MoB_{it} + \beta_2 ATM_{it} + \beta_3 POS_{it} + \beta_4 AgB_{it} + \beta_5 InB_{it} + \beta_6 MoW_{it} + v_{it} \quad (2)$$

Where:

FI_{it} = Financial inclusion at t period;

β_0 = the constant to be estimated by the model;

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ = Coefficient indicating influence of independent variables on the dependent variable;

MoB_{it} = Mobile banking of commercial banks at t period;

ATM_{it} = Automated Teller Machine of commercial banks at t period POS_{it} = Point of Sales of commercial banks at t period;

AgB_{it} = Agent Banking at t period;

InB_{it} = Internet Banking of commercial banks at t period;

MoW_{it} = Mobile Wallet at t Period;

$t = 2015 \dots 2024$;

$i = 1, 2, 3 \dots 17$;

V_{it} = inherent error in the model.

Choosing Random Effect vs Fixed Effect Model. A random effects model is probably best if the omitted variables are uncorrelated with the explanatory variables. It will produce unbiased estimates of the coefficients, use all the data available, and produce the smallest standard errors. If there are omitted variables, and these variables are correlated with the variables, the use of fixed-effects model is advisable. The idea is that whatever effects the omitted variables have on the subject at one time, they will also have the same effect at a later time; hence their effects will be constant, or ‘fixed’. However, in order for this to be true, the omitted variables must have time-invariant values with time-invariant effects (Richard, 2019). Hence, the needs to conduct the Hausman test to choose between fixed-effects and random-effects. Hausman test is a test that whether the errors are correlated with the regressors, the null hypothesis is they are not correlated with the regressors.

Hypothesis for Hausman Test: H_0 = Random effect model is appropriate against H_a = Fixed effect model is appropriate. When the Chi-squared value is smaller than 0.05 (i.e. significant), we use fixed effects. In other words, it tests for the statistical significance of the difference between the coefficient estimates obtained by fixed effects and by random effects. Under then null hypothesis that the random effect estimates are efficient and consistent, and fixed effects estimates are inefficient.

For two estimators as: $\hat{\beta}_{FE}$ (fixed effect) and $\hat{\beta}_{RE}$ (random effect), the hausman test statistic is computed

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' [Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})]^{-1} (\hat{\beta}_{FE} - \hat{\beta}_{RE}) \quad (3)$$

Where,

$\hat{\beta}_{FE}$ is the estimator from the fixed effects model.

$\hat{\beta}_{RE}$ is the estimator from the random effects model.

$Var(\hat{\beta}_{FE})$ and $Var(\hat{\beta}_{RE})$ are the variance-covariance matrices of the two estimators.

Result and Discussion

Descriptive Analysis

Data have been analyzed using both descriptive and regression statistics. Accordingly, Figure 3 to Figure 8 provides a summary of the descriptive of the trends of number of accounts and digital financial services for seventeen commercial banks from the year 2015 to 2024.

As the above figures shows the strong growth in initial years (2016-2020), there was an explosive growth phase for mobile banking, agent banking, internet banking, and mobile wallets, especially between 2016 and 2019. This growth likely reflects the increasing access to mobile phones and digital infrastructure across Ethiopia, along with government and financial sector efforts to improve financial services access. Mobile banking, internet banking, and mobile wallets saw significant spikes in 2020, driven by the pandemic and the increased reliance on digital financial services for safety and convenience. Growth rates for most digital services start to moderate in 2021 and beyond, as the initial phase of rapid adoption slows down. For instance, mobile banking and agent banking saw a decline after their early successes, with growth rates tapering off. ATM usage and POS systems showed slower but steady growth in later years, indicating more gradual adoption as people became accustomed to these services. Mobile wallets and agent banking remain key growth areas throughout the period, with mobile wallets seeing a solid rise in 2023-2024, and agent banking showing a recovery and stabilization after some dips.

Generally, the data indicates that Ethiopia has made substantial progress in financial inclusion and digital financial services. There was a rapid expansion of services in the early years (2016-2020), especially mobile banking, internet banking, and mobile wallets. However, as the adoption of digital services matures, growth rates are moderating, and further expansion will likely require overcoming challenges such as infrastructure development, customer education, and the fostering of trust in digital financial platforms. Agent banking and mobile wallets appear to continue as key drivers of financial inclusion and digital financial services growth in Ethiopia.

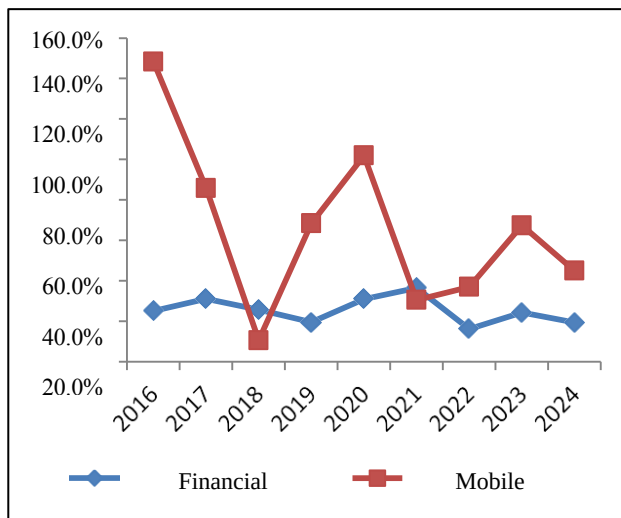


Figure 3. Trends of no. of accounts & mobil banking.

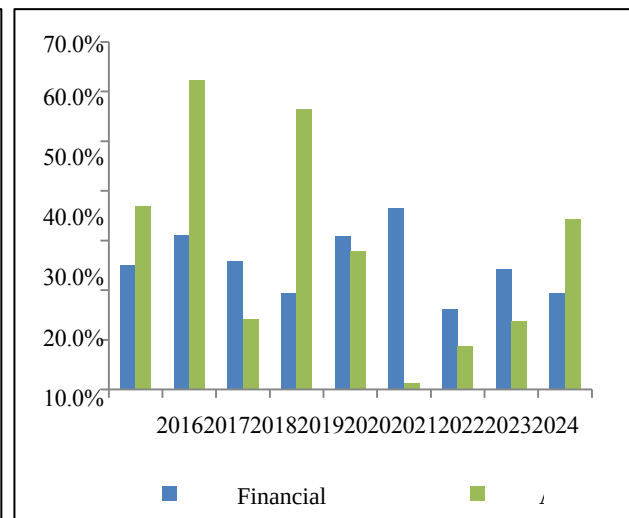


Figure 4. Trends of no. of accounts & ATM.

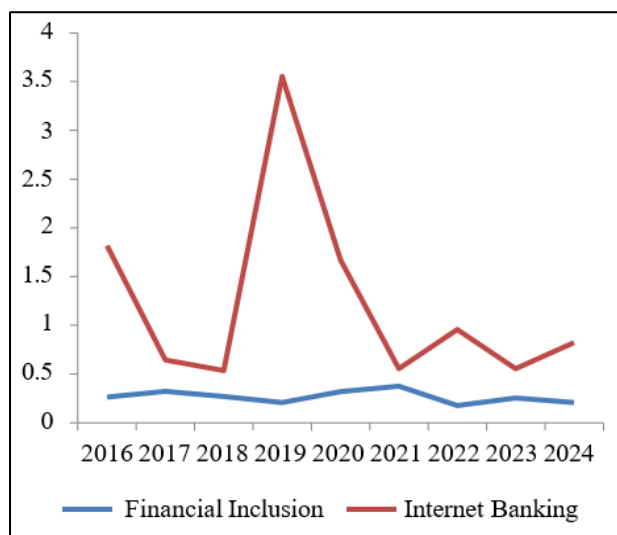


Figure 5. Trends of no. of accounts & internet banking.

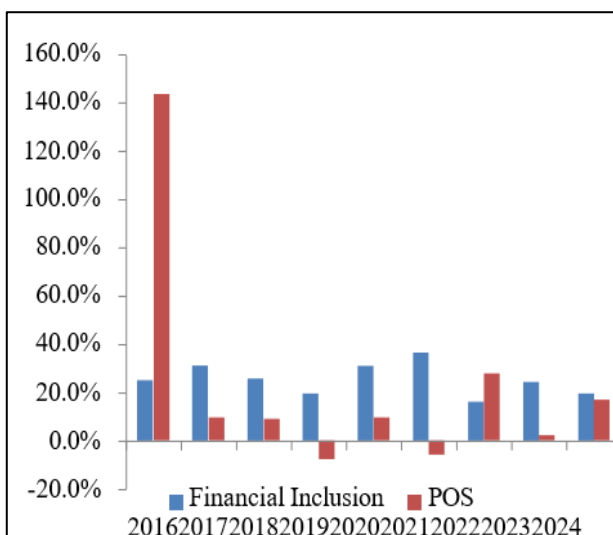


Figure 6. Trends of no. of accounts & POS.

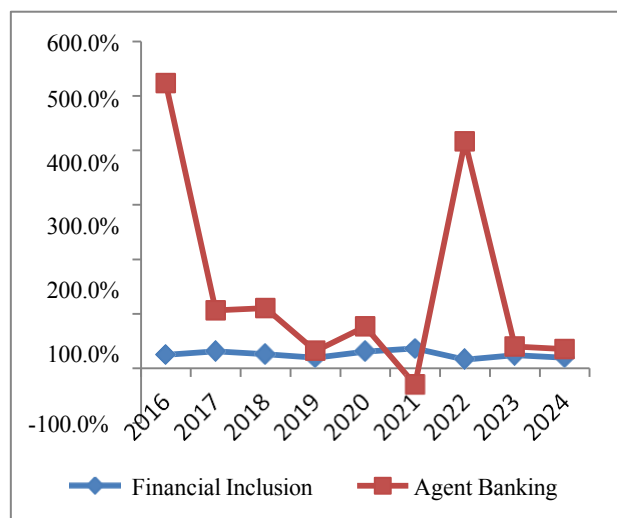


Figure 7. Trends of no. of accounts & agent banking.

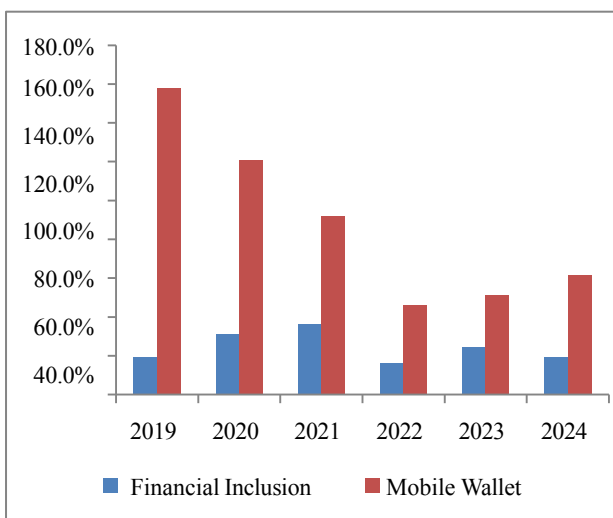


Figure 8. Trends of no. of accounts & mobile wallet.

Empirical Results and Interpretation

Diagnostic Tests and Interpretations

Prior to the regression analysis, data was tested for classical linear regression assumptions and panel data model selection was made based on Hausman test results.

As presented in Table 1, there is no correlation above 0.9 in this study according to Hair and Anderson. Hence, it can be concluded in this study that there is no problem of multicollinearity, thus enhanced the reliability for regression analysis. Additionally multicollinearity (Table 2) was tested by variance inflation factor it was computed to detect the problem of multicollinearity for significant continuous explanatory variables based on t-test. Since, the VIF values for continuous variables were found to be very small; less than 10, indicating that no serious or absence of multi-collinearity between explanatory variables.

Table 1

Correlation Test

	FI	MOB	ATM	POS	InB	AgB	MoW
FI	1						
MOB	0.7903*	1					
ATM	0.7447*	0.8198*	1				
POS	0.7950*	0.6399*	0.8039*	1			
InB	0.0756	0.3412*	0.0888	0.1475	1		
AgB	0.8125*	0.7975*	0.7013*	0.5072*	-0.0299	1	
MoW	0.8071*	0.7975*	0.7271*	0.5427*	0.0272	0.7503*	1

Table 2

Multicollinearity Test

Variable	VIF	1/VIF
MoB	4.76	0.210212
ATM	8.44	0.118507
POS	5.76	0.173587
InB	2.17	0.461382
AgB	2.88	0.34716
MoW	3.99	0.250925
Mean VIF	4.66	

Source: Own computed by using stata 15.

Table 3

Hausman Test for Fixed Effect (FE) and Random Effect (RE)

	-----Coefficients-----			
	(b)	(B)	(b-B)	Sqrt (diag (V _b -V _B))
	fixed	random	Difference	S.E.
MoB	1.474765	0.0631759	1.41159	0.4222935
ATM	5328.436	5686.33	-357.8948	169.3978
POS	361.3769	1006.884	-645.5074	237.7746
InB	0.19386	-0.0183421	0.2122021	0.1360765
AgB	42.11405	76.23557	-34.12151	8.976976
MoW	0.4331249	0.3965034	0.0366215	0.0316168

Notes: b = consistent under Ho and Ha, obtained from xtreg; B = inconsistent under Ha, efficient under Ho, obtained from xtreg;
 Test: Ho: difference in coefficients not systematic, $\chi^2(5) = (b-B)[(V_b-V_B)^{-1}](b-B) = 1.19$, Prob > $\chi^2 = 0.1653$.

Source: Own computed by using stata 15.

As it was presented in Table 3 in Hausman specification test result, the P-value of a model is 0.1653, which is more than 5% level of significance, we are fail to reject the null hypothesis; hence, the random effect model is appropriate model for this data than fixed effect model.

Random Effect Results and Discussions. The regression results of the balanced panel data are presented in Table 4. Further, the decision to employ random effect estimation technique was taken after conducting the Hausman test. Fixed effect estimation technique is also prioritized because it produces consistent results as well as robustness of the estimation, unlike random effect estimation technique. So, because the value of Chi-square is greater than 5% significance level, Random effects are employed for the sample period. The results are shown in Table 4.

Table 4

Fixed Effect and Random Effect Results

Variables	Fixed	Random
MoB	2.082*** -0.257	1.718*** -0.338
ATM	916 -707	2,838*** -878.2
POS	-661.9 -426.8	1,193*** -357.1
InB	-1.223*** -0.296	-1.314*** -0.361
AgB	-46.32 -32.74	-52.19 -45.79
MoW	0.306*** -0.103	0.489*** -0.134
Constant	3.346e+06*** -508,204	802,855** -397,201

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

Source: Own computed by using stata 15.

The Table 4 presents the random effect estimation results of a regression analysis examining the effect of digital financial services (DFS) on financial inclusion, specifically the number of accounts in Ethiopia. The positive coefficient for mobile banking (MOB) indicates that an increase in mobile banking access leads to a significant increase in the number of financial accounts. Specifically, for each unit increase in mobile banking, the number of accounts increases by 1.718. This finding implies that Mobile banking has a significant potential to bridge the gap for individuals who might not have traditional access to banks, such as those living in rural areas or those who face geographical, financial, or physical barriers to accessing bank branches. The ability to access banking services through mobile phones can thus provide people with easier, more convenient ways to manage their finances. This suggests that mobile banking plays a critical role in enhancing financial inclusion in Ethiopia.

As it was hypothesized, there is a positive relationship between mobile banking and financial inclusion, and the association becomes material and significant. The influence of mobile banking users on financial inclusion, in Ethiopia has positive and statistically significant. A similar conclusion by Etim (2014) revealed that mobile banking and mobile money adoption for financial inclusion in Nigeria founds that financial inclusion had positive impact and number of account holders increased as a result of mobile banking and mobile money adoption. Another study in Kenya tested the effect of mobile banking on financial inclusion in Kenya. The study results revealed that mobile banking has a significant positive effect on financial inclusion in Kenya.

The positive coefficient for ATMs indicates a significant relationship between the availability of ATMs and the number of financial accounts in Ethiopia. Specifically, each additional ATM contributes to an increase of 2,838 financial accounts, highlighting the importance of access to automated banking services in encouraging people to open and actively use bank accounts. This effect is particularly relevant for improving financial inclusion, as ATMs provide a convenient, accessible, and less time-consuming way for individuals to engage with the formal banking system. The widespread presence of ATMs enables individuals in both urban and rural areas to perform essential banking functions without the need to visit a bank branch, which can be especially

beneficial for those in remote or underserved regions.

This result aligns with findings by Ehiedu et al., who observed that increased ATM penetration in Nigeria also enhanced financial inclusion, suggesting a broader regional trend. In Ethiopia, as more ATMs are introduced and become accessible to the general population, there is likely to be a corresponding rise in the number of individuals who engage with formal financial institutions, thereby contributing to greater financial inclusion. Overall, the presence of ATMs plays a crucial role in bridging the gap between people and financial services, making it easier for them to open accounts, access their funds, and participate in the financial system. Expanding ATM networks in Ethiopia can therefore be seen as a key strategy for enhancing financial inclusion, especially in areas where traditional bank branches are scarce.

The positive and significant effect of Points of Sale (POS) terminals on financial inclusion in Ethiopia emphasizes the vital role that electronic payment systems play in enhancing access to financial services. According to the coefficient for POS terminals, an increase in POS terminals by one unit increases the number of accounts by 1,193. This demonstrates that POS terminals, which are widely used for payment transactions, not only facilitate everyday purchases but also contribute to the broader goal of financial inclusion by encouraging more individuals to open and actively use bank accounts.

The presence of POS terminals helps integrate individuals into the formal financial system by providing a convenient and accessible method for financial transactions, especially in locations where banking infrastructure is limited. By enabling cashless transactions, POS terminals reduce reliance on physical currency, making financial services more efficient and secure. This, in turn, incentivizes more people to engage with the formal banking sector, increasing account ownership and overall financial access. These findings are consistent with Okaro (2016), who found similar effects of electronic payment systems on financial inclusion in Nigeria.

The negative coefficient for internet banking in the context of Ethiopia suggests an unexpected relationship, where an increase in internet banking services is associated with a decrease in the number of financial accounts. Specifically, for each increase in internet banking, the number of financial accounts decreases by 1.314. This result contradicts the general expectation that internet banking would promote greater financial inclusion, as observed in other studies (e.g., Acar & Çıtak, 2019; Friedline et al., 2019; Liu et al., 2020), where internet banking was found to enhance financial access and account ownership.

In the Ethiopian context, several factors may explain this negative relationship. One potential reason could be limited internet access and connectivity issues, which may hinder the widespread adoption of internet banking services. Ethiopia faces challenges in terms of internet infrastructure, with many rural and underserved areas lacking reliable internet connections, making it difficult for individuals to engage with online banking platforms. Another possible factor is the low level of familiarity or comfort with online banking, particularly among certain demographic groups. People who are less educated or older may be more hesitant or unwilling to use internet banking services due to a lack of digital literacy or a preference for more traditional banking methods. Additionally, trust in digital financial services might be lower among populations unfamiliar with the security and functionality of online banking.

The positive coefficient for Mobile Wallet Banking demonstrates a strong and significant relationship between the availability of mobile wallet services and the increase in financial accounts in Ethiopia. Specifically, each unit increase in mobile wallet banking is associated with a 0.489 increase in the number of financial accounts. This finding highlights the critical role of mobile wallet services in driving financial inclusion, especially in a country like Ethiopia, where traditional banking infrastructure may be limited or difficult to access, particularly

in rural and underserved areas. Mobile wallet banking also provides a cost-effective way for individuals to manage their finances, reducing the need for physical travel to banks, which can be time-consuming and expensive, especially in rural regions. As mobile penetration continues to rise in Ethiopia, the use of mobile wallets will likely expand, further facilitating financial inclusion.

Generally, mobile banking, ATMs, POS terminals, and mobile wallet banking are crucial drivers of financial inclusion in Ethiopia, significantly increasing the number of financial accounts. In contrast, internet banking and agent banking appear to have more limited impacts, with internet banking showing a negative relationship. These results emphasize the importance of expanding access to mobile and electronic banking services to enhance financial inclusion, particularly in rural and underserved areas.

Conclusion and Recommendation

The study explores the effect of digital financial services (DFS) on financial inclusion in Ethiopia. Its primary objective is to assess how the adoption and use of DFS contribute to expanding access to financial services for various segments of the population, using econometric techniques. For achieving the objective, data were collected from the National Bank of Ethiopia, the study specifically focused on seventeen commercial banks. The random effect estimation of regression result clearly revealed that Mobile banking, ATMs, POS terminals, and Mobile Wallet Banking all has a positive and significant effect on the number of financial accounts in Ethiopia. These services are driving financial inclusion by increasing access to banking services and facilitating the opening of accounts. Internet banking appears to have a negative impact on the number of accounts, which might reflect limited access to or use of internet banking in Ethiopia, possibly due to issues like connectivity or low digital literacy. Agent banking shows no significant effect on financial inclusion in this analysis, suggesting that it may not yet be a major factor in increasing account ownership.

Finally, digital financial services such as mobile banking, ATMs, POS terminals, and mobile wallet banking are key drivers of financial inclusion in Ethiopia, while internet banking and agent banking have more limited impacts. The authors propose that enhancing the adoption of digital financial services (DFS) in both rural and urban areas could play a crucial role in advancing financial inclusion. They argue that such an increase would directly support the financial inclusion strategies of policymakers and banking practitioners. By improving access to digital financial tools, individuals in these regions often underserved by traditional banking systems could be integrated into the formal financial sector. This, in turn, would help achieve broader economic goals, ensuring that more people have access to banking services and financial opportunities, thus contributing to the overall financial inclusion agenda.

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Appendix

Fixed Effect result

```
. xtreg FI MOB ATM POS INB AGB MW_B , fe
```

Fixed-effects (within) regression
Group variable: BID

Number of obs = 74
Number of groups = 16

R-sq:
within = 0.9032
between = 0.9024
overall = 0.8360

Obs per group:
min = 2
avg = 4.6
max = 7

F(6,52) = 80.91
Prob > F = 0.0000

corr(u_i, Xb) = 0.7064

FI	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
MOB	2.082168	.2572821	8.09	0.000	1.565894 2.598443
ATM	916.0063	707.0152	1.30	0.201	-502.7236 2334.736
POS	-661.8591	426.8213	-1.55	0.127	-1518.339 194.6205
INB	-1.223242	.2957046	-4.14	0.000	-1.816617 -.6298677
AGB	-46.31548	32.73608	-1.41	0.163	-112.0052 19.37428
MW_B	.3063725	.1031073	2.97	0.004	.0994726 .5132724
_cons	3345642	508203.7	6.58	0.000	2325856 4365427
sigma_u	4675833.9				
sigma_e	1177990.9				
rho	.94031837	(fraction of variance due to u_i)			

F test that all u_i=0: F(15, 52) = 12.30 Prob > F = 0.0000

Random Effect Result

```
. xtreg FI MOB ATM POS INB AGB MW_B , re
```

Random-effects GLS regression
Group variable: BID

Number of obs = 74
Number of groups = 16

R-sq:
within = 0.8583
between = 0.9527
overall = 0.9492

per gr:
min = 2
avg = 4.6
max = 7

Wald chi2(6) = 758.92
Prob > chi = 0.0000

corr(u_i, X) = 0 (assumed)

FI	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
MOB	1.718104	.3375335	5.09	0.000	1.05655 2.379658
ATM	2837.679	878.235	3.23	0.001	1116.37 4558.989
POS	1192.81	357.0805	3.34	0.001	492.9456 1892.675
INB	-1.313724	.3609943	-3.64	0.000	-2.02126 -.6061883
AGB	-52.18939	45.78556	-1.14	0.254	-141.9274 37.54865
MW_B	.4887384	.1343816	3.64	0.000	.2253553 .7521216
_cons	802855.5	397201.3	2.02	0.043	24355.18 1581356
sigma_u	766710.65				
sigma_e	1177990.9				
rho	.29756665	(fraction of variance due to u_i)			