Science Futures
2026, Vol. 2, No. 2, pp. 174–188
https://doi.org/10.11648/j.scif.20260202.18

Research Article

The Effect of Digital Financial Services on Financial Inclusion in Ethiopia

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Abstract

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

1. Introduction

Financial inclusion is widely recognized as a foundation for enabling individuals and enterprises to obtain affordable and appropriate financial products and services. Expanding access to inclusive financial services for unbanked populations has emerged as a global concern, particularly in developing economies. Access to finance plays a vital role in fostering economic growth and enhancing social welfare. Financial institutions are central to this process, as they facilitate the delivery of financial services across different segments of society [1]. In many countries, the banking sector serves as a key pillar in

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Received: 9 December 2025; **Accepted:** 5 January 2026; **Published:** 2 February 2026

advancing financial inclusion initiatives [2]. In addition, microfinance institutions contribute significantly by providing financial services to rural and urban households, as well as to small and medium-sized enterprises (SMEs) [3]. Although notable improvements have been made, achieving inclusive financing remains a major challenge in developing nations and continues to be a priority for international bodies such as the United Nations [4].

International frameworks established by institutions including the World Bank, IMF, and United Nations emphasize financial inclusion as a mechanism for achieving sustainable social and economic development across Africa. Under the UN's 2030 Sustainable Development Goals (SDGs), expanded access to financial instruments in lower-income economies is viewed as critical for enhancing livelihoods and promoting economic resilience [5]. Extensive research has shown that financial inclusion strengthens financial system sustainability [6], facilitates poverty alleviation [3], supports firm-level expansion [6], and advances both income equality and gender empowerment [7].

In Africa, overall financial integration remains comparatively low despite advancements in information and communication technologies. Key barriers continue to include financial illiteracy, inadequate infrastructure, and demographic limitations related to income, education, age, and gender [8, 9]. However, data from the Global Findex indicate a steady rise in adoption of mobile- and internet-based financial tools, with usage increasing globally from 67% to 76% and within developing economies from 57% to 70% [10]. These trends highlight the growing potential of digital banking platforms to mitigate barriers to financial inclusion.

Financial technology (FinTech) encompasses the innovative delivery of financial products through digital platforms designed to enhance efficiency, accessibility, and affordability beyond traditional banking models [11]. FinTech applications such as mobile payments, peer-to-peer lending, crowd financing, and blockchain platforms illustrate the sector's global reach [12]. Investment in FinTech expanded rapidly over the past decade, reinforcing its recognition as a transformative force for inclusion strategies by enabling unbanked populations to access secure financial channels at lower costs.

Ethiopia was identified among priority countries under the World Bank's Universal Financial Access (UFA2020) program. While adult account ownership rose from 22% in 2014 to 35% in 2017, levels remain low relative to neighboring countries such as Kenya and Rwanda. Cash transactions continue to dominate daily activities, with limited adoption of digital tools and mobile money services [13, 14]. Although over 13 million mobile phone users remain unbanked, recent regulatory reforms and national digital strategies have positioned DFS as a catalyst for future inclusion particularly through the launch of TeleBirr in 2021.

Despite the global literature documenting links between FinTech and economic growth, empirical evidence concerning its direct contribution to financial inclusion in Ethiopia remains limited. Given the country's ambitious digital transformation agenda, assessing the effectiveness of DFS on improving financial access is timely and necessary.

Moreover, Ethiopia is currently undertaking an ambitious ten-year digital transformation agenda aimed at modernizing its economy and service delivery systems. In this context, the findings of this study contribute to the existing body of knowledge by validating the role of financial technologies in promoting inclusive financial services within developing economies, with particular emphasis on Ethiopia. In addition, the study provides practical insights for managers of financial institutions by highlighting the importance of coordinated efforts to expand digital financial services as a means of enhancing financial inclusion. Accordingly, the primary objective of this research is to examine the impact of digital financial services on financial inclusion in Ethiopia using formal econometric techniques, specifically panel data analysis. The structure of the paper is as follows: Section 3 reviews the relevant literature; Section 4 outlines the data sources and research methodology; Section 5 presents and discusses the empirical results; and Section 6 concludes the study and offers policy recommendations.

2. 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 [15]. 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 [16]. 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 National Bank of Ethiopia (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.

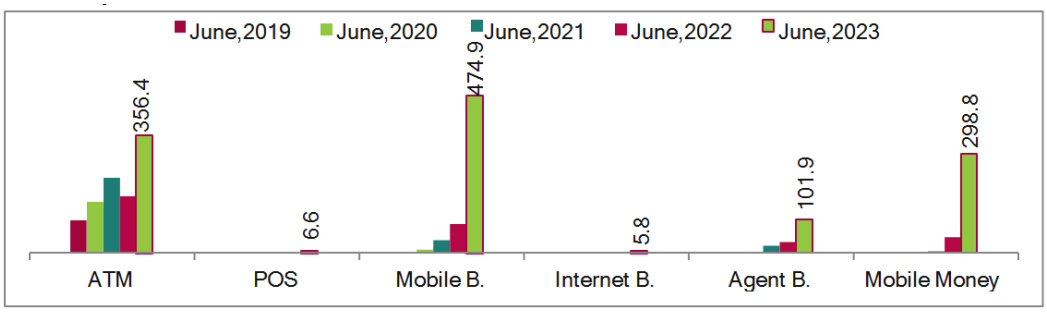

Figure 1. *Trends of Financial Transaction Volume per Digital Channel (in Trillion) in Ethiopia.*

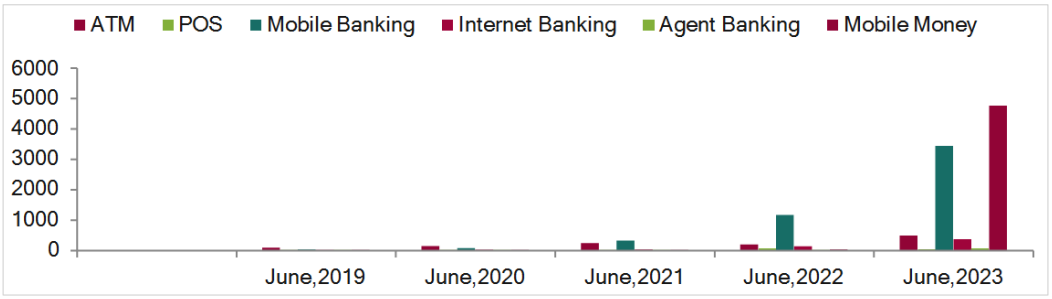

Figure 2. *Trends of Financial Transaction (Value in Billion Birr) in Ethiopia.*

Figure 1, 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 and 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.

3. Literatures Review

3.1. Theoretical Review

3.1.1. Financial Inclusion Theories

[17] Outlines several perspectives guiding financial inclusion strategies, including public good theory, dissatisfaction theory, vulnerable group theory, and systems theory. These frameworks emphasize that financial service delivery extends beyond profit and operates as a social intervention aimed at targeting excluded populations. Vulnerable groups women,

youth, the elderly, and low-income households remain the primary beneficiaries. Additionally, the special agent theory argues that financial institutions and technology firms act as delivery agents, partnering with governments to expand outreach into unbanked communities [17, 18]. The public service theory further positions financial inclusion as a governmental obligation, emphasizing public accountability and centralized coordination.

3.1.2. Financial Inclusion and Financial Technology

Financial inclusion refers to the process of expanding access to essential financial services to all segments of society by minimizing both economic and non-economic barriers. The World Bank defines financial inclusion as the availability of affordable and appropriate financial services such as payments, savings, credit, transactions, and insurance for individuals and businesses, delivered in a sustainable and responsible manner [10]. Similarly, [19] describe financial inclusion as the extent to which households and firms particularly low-income populations and small and medium-sized enterprises (SMEs) are able to utilize formal financial services. Across the literature, there is broad consensus that financial inclusion aims to improve access to finance for underserved and marginalized communities. Providing formal financial services to previously unbanked populations is widely regarded as a mechanism for reducing income inequality and improving economic participation [5]. [10] further emphasize that financial inclusion ensures safe, efficient, and convenient delivery of financial services to all adults through both traditional banking platforms and digital financial innovations.

Financial technology (FinTech) encompasses digital innovations and alternative banking solutions developed by technology-based enterprises, along with modern digital platforms established by conventional financial institutions. Evidence from developing economies indicates that FinTech products particularly mobile money services have a substantial positive effect on financial inclusion by expanding outreach to populations previously excluded from formal banking systems [20]. Studies also demonstrate that digital banking channels, including mobile banking, internet banking, and ATM networks, significantly support financial inclusion objectives by increasing service availability and account ownership [21]. Research conducted in Ghana similarly confirms that the emergence of integrated fintech ecosystems has strengthened national financial inclusion efforts [4].

Because most digital financial services operate via mobile phones, internet platforms, and short-message services (SMS) through telecommunications infrastructure, individuals residing in remote or underserved locations can gain affordable access to financial transactions without visiting physical bank branches. Although infrastructure limitations remain a concern in many low-income countries, digital financial platforms continue to demonstrate strong potential to overcome geographic distance and transaction cost barriers [22]. In the African context, fintech adoption has been associated not only with expanded financial access but also with improvements toward gender equality [4] and income distribution [5]. Furthermore, empirical studies across the region indicate that digital banking services particularly mobile banking play an especially important role in improving access to finance within rural and underserved communities [21].

3.2. Review of Empirical Studies

In terms of the study of the determinants of financial inclusion, [23] 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, increased internet connectivity has been found to exert a positive and significant impact on financial inclusion.

Other cross-country studies analyzing African economies reveal that mobile infrastructure and mobile phone usage positively affect financial inclusion [24]. Research focusing on sub-Saharan Africa further indicates that indicators such as the number of ATMs, POS terminals, internet providers, and mobile banking services significantly improve financial inclusion outcomes [25].

Several studies explicitly analyze the impact of digital financial services on financial inclusion. Evidence shows that access to mobile financial services significantly increases savings behavior by reducing distance and transaction costs [26]. Empirical findings from Ghana demonstrate that mobile subscriptions and ICT adoption significantly enhance financial inclusion, suggesting that digital financial services strengthen financial sector performance [27].

Research examining technology diffusion across countries also confirms that internet usage, ATM density, bank branches, and private sector credit all exert a positive and significant effect on the number of deposit accounts [28]. Country-level evidence from Kenya further confirms that digital finance strategies particularly mobile banking has a statistically significant impact on financial inclusion, followed by ATMs, banking agents, and online banking [29]. Survey-based studies similarly conclude that electronic payment systems, including bank cards, mobile banking, internet banking, and online remittances, play a critical role in improving financial performance and inclusion [30].

4. Methodology and Data Sources

4.1. Data Sources and Variable Description

The data used in this study to assess the effect of digital financial services on financial inclusion were obtained from the

National Bank of Ethiopia, covering the period from 2014/15 to 2023/24. Ethiopia has 32 commercial banks, one government-owned bank, and one development bank. From these, seventeen commercial banks were selected based on years of establishment and operational experience. The dataset is a balanced panel, capturing both cross-sectional and time-series dynamics. Digital financial services considered in this study include internet banking, mobile banking, agent banking, POS machines, and ATMs. Financial inclusion is measured using the number of deposit accounts, as widely adopted in the literature [31]. 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:

a) Mobile banking and financial inclusions

A growing body of research suggests that the expansion of mobile technology has substantially improved access to traditional banking services. Financial technologies, particularly mobile money, play a significant role in advancing financial inclusion in developing economies [20]. Beyond mobile money, other digital financial services such as internet banking, mobile banking applications, and automated teller machine (ATM) services have also been shown to positively support financial inclusion initiatives [21]. Moreover, [32] highlights that mobile money has been especially effective in empowering women in Nairobi by facilitating instant remittances and payments, while also providing a secure mechanism for saving money. Consistent with these findings, additional studies confirm the positive contribution of mobile money to financial inclusion [33]. Based on this empirical evidence, the following hypothesis is proposed:

b) Automated teller machine and financial inclusion

The expansion of banking infrastructure including ATMs and POS terminals has improved access to financial services in low-income regions [34]. ATMs enable previously excluded individuals to open and use bank accounts, thereby strengthening inclusion. Evidence from India highlights the role of ATMs as foundational tools for financial inclusion, despite persistent infrastructure gaps relative to global averages [35].

H2: Automated teller machines (ATMs) have a positive and significant effect on financial inclusion.

c) Point of sale terminal (POS) and financial inclusion

Electronic payment systems such as POS terminals expand transaction options, reduce reliance on cash, and enhance financial inclusion [36]. Payment infrastructures including clearing houses, electronic money systems, and card-processing platforms further strengthen access to formal financial services [37]. Empirical findings confirm that POS availability positively influences account penetration and new account creation [38].

H3: POS terminals have a positive and significant effect on financial inclusion.

d) Internet banking and financial inclusion

Advances in internet technology have significantly contributed to the growth of electronic banking services by enabling remote and time-independent access to financial products [39]. The evolution of financial technology is closely linked to improvements in internet connectivity and digital infrastructure [11].

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

e) Agent banking and financial inclusion

Agent banking enables trusted local retailers to deliver basic financial services without requiring customers to visit traditional bank branches [40]. Evidence from African economies demonstrates that agent banking significantly improves financial inclusion among low-income populations [41]. Due to its affordability and accessibility, agent banking is widely regarded as an effective mechanism for expanding financial outreach.

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

f) Mobile wallet banking and financial inclusion

Mobile wallet banking and financial inclusion are closely interconnected. As mobile wallet technologies continue to advance, they offer substantial opportunities to build more inclusive financial systems by reducing barriers related to geographic location, cost, and access to formal financial services. Through lower transaction fees, improved digital literacy, and the availability of diverse financial products, mobile wallets have the potential to significantly enhance financial inclusion among populations that have traditionally been excluded from the formal banking sector.

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

4.2. 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:

$$Yit = X_{it}' \beta + V_{it} \quad (1)$$

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, N and t = 1, 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, Vit = Composite error term (Vit = αi + uit), the most important part of the analysis, where αi = unobserved unit-specific error or (unobserved heterogeneity), which is unobserved fixed effect or time-invariant and correlated with Xit (fixed effect model), but if uncorrelated (Random effect

model) & specific to each individual, and, uit = 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.

β0 = the constant to be estimated by the model

β1, β2, β3, β4, β5, β6= Coefficient indicating influence of independent variables on the dependent variable

MoBit = Mobile banking of commercial banks at t period

ATMit = Automated Teller Machine of commercial banks at t period POSit =Point of Sales of commercial banks at t period

AgBit = Agent Banking at t period

InBit=Internet Banking of commercial banks at t period MoWit=Mobile Wallet at t Period

t = 2015 to 2024

i = 1, 2, 3 17

Vit = inherent error in the model

Choosing random effect Vs fixed effect model

A random effects model is appropriate when unobserved factors are assumed to be uncorrelated with the explanatory variables. Under this assumption, the model yields unbiased and efficient coefficient estimates, utilizes both within- and between-entity variations, and generally produces smaller standard errors. However, when unobserved variables are correlated with the regressors, the fixed effects model is more suitable. The fixed effects approach assumes that the influence of such unobserved characteristics remains constant over time, allowing their effects to be controlled through entity-specific intercepts. For this assumption to hold, the omitted variables must be time-invariant and exert consistent effects across the study period [42].

To determine the appropriate model, the Hausman specification test is employed. This test evaluates whether the error terms are correlated with the regressors. The null hypothesis states that the random effects model is appropriate, while the alternative hypothesis supports the fixed effects model. If the Chi-square statistic is statistically significant (p-value < 0.05), the null hypothesis is rejected in favor of the fixed effects model. In essence, the Hausman test examines whether there is a systematic difference between the coefficient estimates obtained from fixed effects and random effects models. Under the null hypothesis, the random effects estimators are both consistent and efficient, whereas the fixed effects estimators, although consistent, are relatively inefficient.

For the two estimators, the fixed-effects estimator $\hat{\beta}_{FE}$ and the random-effects estimator $\hat{\beta}_{RE}$, the Hausman test statistic is defined as:

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

where:

$\hat{\beta}_{FE}$ denotes the coefficient estimator obtained from the fixed effects model.

$\hat{\beta}_{RE}$ denotes the coefficient estimator obtained from the random effects model.

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

5. Result and Discussion

5.1. 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.

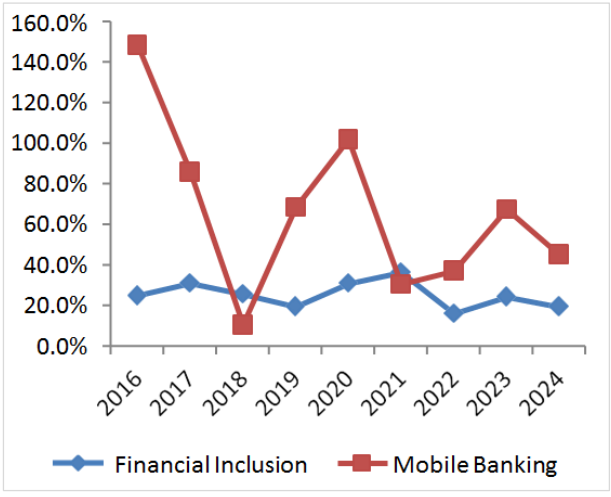

Figure 3. *Trends of no. of accounts &Mobil Banking.*

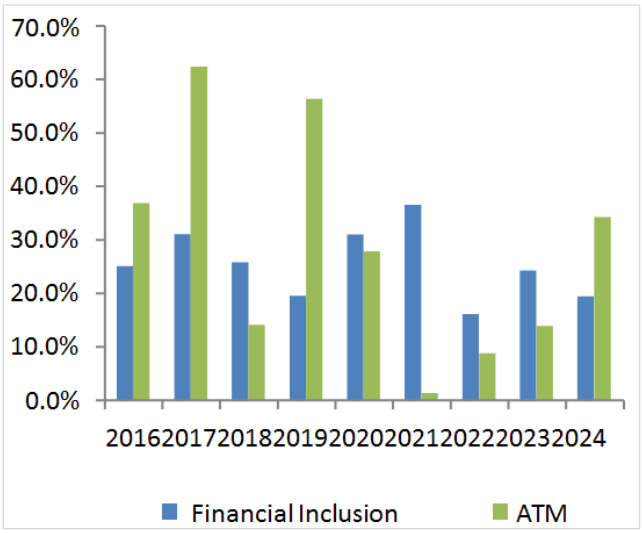

Figure 4. Trends of no. of Accounts &ATM.

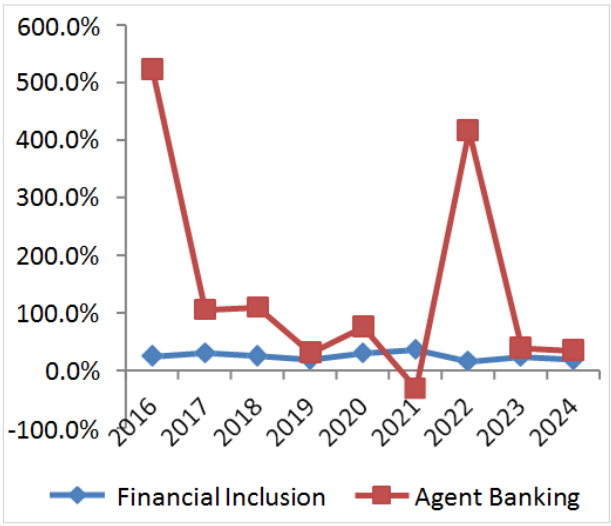

Figure 7. Trends of no. of accounts &Agent Banking.

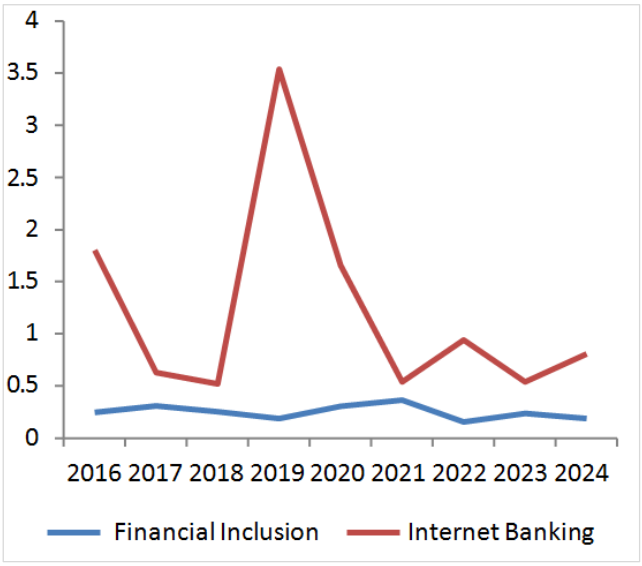

Figure 5. Trends of no. of accounts &Internet Banking.

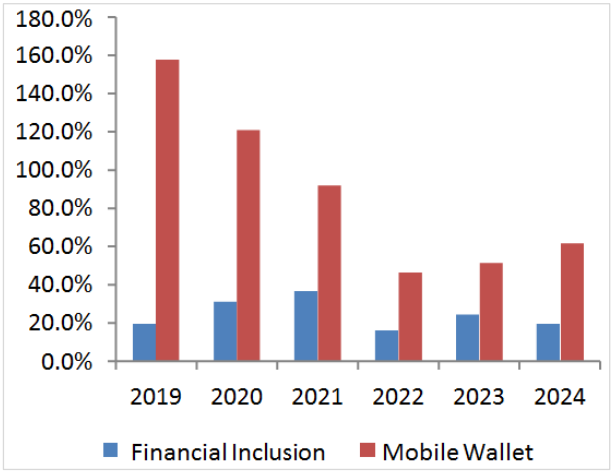

Figure 8. Trends of no. of accounts &Mobile Wallet.

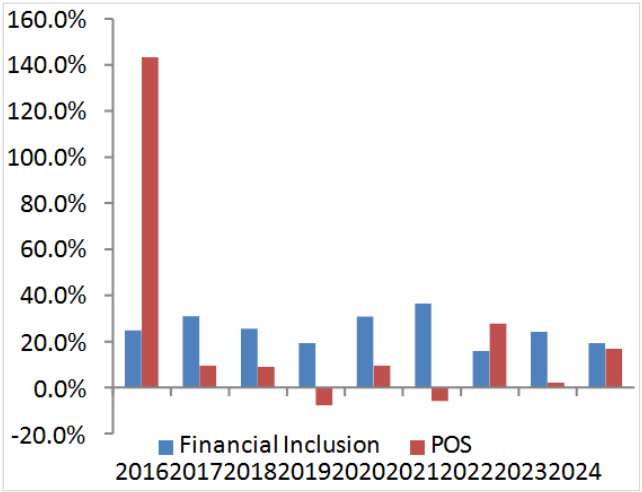

Figure 6. Trends of no. of accounts &POS.

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.

5.2. Empirical Results and Interpretation

5.2.1. 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.

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

As shown in Table 1, none of the correlation coefficients exceed the threshold value of 0.9, as suggested by Hair and Anderson, indicating the absence of severe pairwise correlations among the variables. Therefore, multicollinearity is not a concern in this study, enhancing the reliability of the regression results. In addition, multicollinearity was further assessed using the Variance Inflation Factor (VIF), as reported in Table 2. The VIF values were calculated for the key continuous explanatory variables to detect potential multicollinearity issues. Since all VIF values are well below the commonly accepted cutoff value of 10, the results confirm that there is no serious multicollinearity among the explanatory variables.

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

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
chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
=1.19
Prob>chi2 =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.

5.2.2. 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***	1.718***
	-0.257	-0.338
ATM	916	2,838***
	-707	-878.2
POS	-661.9	1,193***
	-426.8	-357.1
InB	-1.223***	-1.314***
	-0.296	-0.361
AgB	-46.32	-52.19
	-32.74	-45.79
MoW	0.306***	0.489***
	-0.103	-0.134
Constant	3.346e+06***	802,855**

Variables	Fixed	Random
	-508,204	-397,201

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 hypothesized, mobile banking has a positive and statistically significant relationship with financial inclusion in Ethiopia. The findings indicate that increased adoption of mobile banking services contributes meaningfully to expanding access to financial services. Similar results have been reported in other African contexts. For instance [43]. found that the adoption of mobile banking and mobile money in Nigeria significantly increased the number of account holders and enhanced overall financial inclusion. Likewise, a study conducted in Kenya demonstrated that mobile banking has a strong positive effect on financial inclusion, reinforcing the role of digital financial services in broadening access to formal financial systems.

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 [44], 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., [12, 45, 46]), 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.

6. 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 results 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.

Abbreviations

ACU	Automated Clearing House
ARDL	Autoregressive Distributed Lag
ATM	Automated Teller Machine
DFS	Digital Financial Services
EMS	Electronic Money System
FinTech	Financial Technology
G2P	Government-to-Person
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IMF	International Monetary Fund
ITU	International Telecommunication Union
MFI	Microfinance Institution
NBE	National Bank of Ethiopia
NGO	Non-Governmental Organization
PSNP	Productive Safety Net Programme
POS	Point of Sale
SDG	Sustainable Development Goals
SMS	Short Message Service
SMSE	Small and Medium-Sized Enterprises
UFA	Universal Financial Access
UN	United Nations
WB	World Bank

Author Contributions

Antehun Desho is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

1) Fixed Effect result

Table A1. *Fixed Effect Stata output.*

xtreg FI MOB ATM POS INB AGB MW_B, fe

Fixed-effects (within) regression Number of obs = 74

Group variable: BID Number of groups =16

Within = 0.9032 Min = 2

R-sq: Between = 0.9024 Obs per group: Avg = 4.6

Overall = 0.8360 Max = 7

F(6,52) = 80.91

corr(u_i, Xb) = 0.7064 Prob > F = 0.0000

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

2) Random Effect Result

Table A2. *Random Effect Stata output.*

xtreg FI MOB ATM POS INB AGB MW_B, fe

Fixed-effects (within) regression Number of obs = 74

Group variable: BID Number of groups =16

Within = 0.8583 Min = 2

R-sq: Between = 0.9527 Obs per group: Avg = 4.6

Overall = 0.9492 Max = 7

Wald chi2(6) = 758.92

corr(u_i, Xb) = 0 (assumed) Prob > chi2 = 0.0000

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 dueto u_i)					

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