MJBEM 4 (2) 190-199

MJBEM

Malaysian Journal of Business, Economics and Management

journal homepage: https://mjbem.com.my/

Digital Finance and Agricultural Credit in Nigeria: An Econometric Analysis

Tajudeen Idera Abdulmajeed*[1], Gbenga Festus Babarinde[2], Dauna Y.[3], and Bashirat Oluwafunke Oloyin-Abdulhakeem[1]

[1]*Department of Banking and Finance, University of Abuja, FCT, Abuja, Nigeria.*
[2]*Department of Banking and Finance, Modibbo Adama University, Yola, Adamawa State, Nigeria.*
[3]*Department of Agricultural Economics, Modibbo Adama University, Yola, Adamawa State, Nigeria.*

KEYWORDS

Digital Finance Innovation
Agricultural Credit
ATM
POS
Nigeria

ARTICLE HISTORY

Received 4 February 2025
Received in revised form 18 November 2025
Accepted 20 December 2025
Available online 31 December 2025

ABSTRACT

Digital financial innovations are increasingly viewed as mechanisms for improving credit access across economic sectors, particularly agriculture. However, empirical evidence on the effects of specific digital financial instruments on agricultural credit in Nigeria remains limited. This study examines the influence of Automated Teller Machines (ATM), Point of Sale (POS) systems, and web-based payment platforms (web-pay) on agricultural credit allocation by Deposit Money Banks (DMBs) in Nigeria from the first quarter of 2009 to the fourth quarter of 2021. Data were obtained from the Central Bank of Nigeria (CBN) Statistical Bulletin. The study employs Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), and Canonical Cointegrating Regression (CCR), alongside Granger causality analysis, to investigate long-run relationships and causal dynamics. The findings confirm a long-run equilibrium relationship between digital financial transaction channels and agricultural credit. ATM and POS transactions exhibit positive and statistically significant effects on agricultural credit, with coefficients of 0.211665 and 0.067034 respectively. Conversely, web-pay transactions show a negative but statistically significant association with agricultural lending. Causality analysis reveals bidirectional relationships between ATM transactions and agricultural credit, as well as between POS transactions and agricultural credit, indicating mutual reinforcement. In contrast, a unidirectional causal flow is observed from agricultural credit to web-pay transactions. The results suggest that ATM and POS technologies are key drivers of agricultural credit distribution in Nigeria, while web-pay platforms play a limited role. The study recommends increased adoption of ATM and POS technologies by both agricultural stakeholders and DMBs, particularly in rural areas, to enhance financial inclusion, credit access, and agricultural productivity.

1. INTRODUCTION

Recent scholarly attention has increasingly been directed toward the relevance of digital finance, largely due to its potential to simplify financial processes for individuals, enterprises, and the broader economy (Shekhar et al., 2023). Digital financial accessibility has made it possible to offer a wide array of services, such as mobile and online banking, thereby transforming how financial interactions are conducted (Abdulmajeed et al., 2024). The financial industry has witnessed considerable growth, driven by innovative technologies and evolving business models that have led to the emergence of both new entrants and technology-driven competitors within traditional financial sectors. These entities, by leveraging digital tools, have managed to deliver services that are not only more efficient but also more profitable and appealing to consumers.

Technological advances have facilitated the proliferation of financial solutions including internet banking, smart banking platforms, electronic wallets, mobile wallet systems, and the use of debit and credit cards. These developments have significantly benefited users by offering streamlined and user-friendly financial services (Shekhar et al., 2023).

*Corresponding author:
E-mail address: Tajudeen Idera Abdulmajeed < abdulmajeed.idera@uniabuja.edu.ng >.
https://doi.org/10.56532/mjbem.v4i2.122
2948-4928/

For a country such as Nigeria, where national revenue has been historically dependent on oil and gas, economic diversification is both urgent and essential. A shift towards alternative income-generating sectors is considered critical (Abdulmajeed et al., 2023). Agriculture presents itself as a viable economic pillar if adequate support structures such as funding mechanisms, grant programs, and business-friendly environments are instituted. One effective approach to fostering growth in agribusiness could be through the integration of digital financial tools (Agbaeze et al., 2023). The effectiveness of digital finance in supporting agricultural expansion is evidenced by the significant rise in credit allocated to the sector by deposit money banks in Nigeria. From ₦135.70 billion in 2009, agricultural credit increased dramatically to ₦1,812.47 billion by 2022 (Central Bank of Nigeria [CBN], 2022). This upward trend suggests that financial technology has introduced transformative opportunities in banking services by creating digital infrastructures that enhance financial inclusion.

In Nigeria, one of the key advantages associated with digital financial innovations lies in the ability to provide banking and financial services remotely without requiring face-to-face contact thus improving accessibility and convenience for users across diverse geographical locations (Babarinde, 2023). The central bank of Nigeria lunched National Financial Inclusion Strategy (NFIS) in 2012 emphasis on digital payment systems and gave the impulse to the digitalization of the banking and financial service provision in the country. Furthermore, the revised of NFIS in 2018 was erected on four considered areas of mobile banking/mobile payments, agency banking, client empowerment and linkage models (CBN, 2018). Currently, digital financial services are subjected by digital/electronic payment services via POS, ATM, webpay, mobile pay, Remita, Nigerian Interbank settlement system (NIBSS) instant payment (NIP), NIBSS electronic funds transfer (NEFTS), NIBSS automated payment services (NAPS), central pay, m-cash, e-bills/pay (Abdulmajeed, et al., 2024).

Limited access to financial services remains a persistent concern, particularly among specific demographic groups and across varying levels of national development (Shekhar et al., 2023). This disparity is especially evident in underserved regions, where access to banking and credit facilities is significantly constrained. The banking industry, which traditionally functions as a conduit between surplus and deficit units by mobilizing savings and directing them toward productive investment in the real sector, has encountered challenges integrating emerging technologies fully into mainstream operations (Onyia, 2019). Although financial innovations offer potential for transformation, the increasing intensity of competition among banks has complicated their seamless adoption. Banks, particularly dominant ones, are placed under considerable pressure to adapt or risk losing market share if digital transformations are not effectively managed. These pressures are compounded by systemic issues that affect agriculturally driven enterprises most notably, inadequate access to capital and skilled labor, especially in rural communities where agriculture is practiced on a commercial scale. The advancement of digital technology within the financial system has led to a shift from conventional banking operations to digitized platforms, facilitating services such as payments, withdrawals, credit disbursements, and loan processing (Agbaeze et al., 2023).

Given these developments and the unique challenges faced by the agricultural sector, there is a compelling need to assess the influence of digital financial services on the provision of credit to agriculture by commercial banks in Nigeria. Although numerous empirical investigations have examined the general relationship between digital financial platforms and bank performance, limited emphasis has been placed on the credit supply dimension (Babarinde et al., 2024; Babarinde, 2023; Menza et al., 2024; Otitoju et al., 2023; Ren et al., 2023; Pakhnenko et al., 2021). Other studies have explored the nexus between digital finance and banking credit (Agbaeze et al., 2023; Adewale et al., 2022; Olowofeso et al., 2017), as well as the broader implications of financial inclusion on economic growth (Dhiaf et al., 2022; Chukwu & Molokwu, 2022; Ozili, 2020; Senou et al., 2019; Shen et al., 2019). In response to these gaps, the present study is designed to explore the relationship between digital financial services and bank lending to Nigeria's agricultural sector. The specific objectives include: evaluating the effect of web-based payment systems on agricultural credit allocation by banks; analyzing the impact of point-of-sale (POS) systems on such credit provision; and assessing how automated teller machine (ATM) usage influences agricultural lending by deposit money banks.

The structure of the study is organized as follows: Section Two reviews relevant literature on digital finance and agricultural credit allocation by banks. Section Three outlines the methodology employed. Section Four presents the findings along with a discussion, while Section Five concludes the study and offers policy recommendations.

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Digital Finance

Digital finance is generally characterized as the provision of financial services facilitated through electronic devices such as mobile phones, computers, or bank cards, which may or may not require internet connectivity, and are supported by reliable digital payment systems (Agbaeze et al., 2023). It has also been described as the execution of financial operations such as payments and transfers via mobile devices, internet-enabled platforms, or card-based technologies (Manyika, 2016). According to Babarinde (2023), this concept encompasses financial transactions performed through digital tools like smartphones, smartcards, and computers, regardless of the presence of internet access. Furthermore, digital finance has been defined by Ozili (2018) as the collection of financial services and transactions that allow individuals, corporate entities, and organizations to access credit, savings, and payment systems online, thereby eliminating the necessity of physical interaction with financial institutions.

The use of digital financial services entails the application of a range of electronic devices and channels, including but not limited to computers, various types of bank cards, point-of-sale (POS) terminals, automated teller machines (ATMs), and internet-based transfer platforms. These technologies enable seamless and rapid financial interactions, allowing both individuals and businesses to send and receive payments efficiently without the need for in-person engagement (Agbaeze et al., 2023). Moreover, as digital infrastructure continues to evolve, the scope of digital finance has expanded

to incorporate financial technology (fintech) applications. These platforms facilitate access to diverse investment options, including digital representations of commodities such as gold ("digital gold"), as well as digital versions of stocks and derivative financial products and services (Abdulmajeed et al., 2024). Access to secure and affordable financial services including payments, credit, insurance, savings, and both domestic and international transfers has been made significantly more attainable through the integration of digital technologies, particularly smartphones and broadband internet, within information and communication systems (Senou et al., 2019). The role of these technological tools has become vital in extending financial inclusion to underserved populations.

Digital finance is broadly understood as the delivery of financial products and services through electronic means, without the requirement for face-to-face interaction between financial institutions and end-users. This form of service delivery is facilitated via internet-enabled or offline digital platforms and devices (Babarinde, 2023). Consequently, digital finance encompasses a wide spectrum of banking and non-banking activities—including payments, online purchases, investments, savings, remittances, and access to credit and loan products—which are conducted through electronic tools such as computers, smartphones, smartcards, automated teller machines (ATMs), and point-of-sale (POS) devices. These services are generally supported by internet infrastructure but may also function in offline environments.

In the context of this study, digital finance is operationalized using three specific indicators: POS banking transactions, web-based financial transactions, and ATM operations.

i. **POS Transactions**: This payment mechanism enables banking services to be carried out at retail or service locations using POS terminals. Transactions are completed using debit or credit cards, and the aggregate transaction value is recorded in billions of Naira.
ii. **Web-Based Transactions**: This channel facilitates the initiation and execution of financial operations through internet-connected platforms, allowing users to conduct transfers, payments, or other services digitally. The cumulative transaction value is also measured in billions of Naira.
iii. **ATM Transactions**: Automated Teller Machines allow users to perform a variety of financial transactions, such as cash withdrawals and account inquiries, using either debit or credit cards. These operations, too, are quantified based on total transaction values denominated in billions of Naira (Abdulmajeed et al., 2024).

2.1.2 Bank Credit Allocation

Bank credit refers to financial resources made available by banking institutions in the form of loans, advances, overdrafts, and various other credit instruments extended to individuals, businesses, or the wider economy (Babarinde, 2023). It has also been conceptualized as the total volume of credit facilities disbursed by banks to support the financial needs of both individuals and corporate entities (Fapetu & Obalade, 2015). In the context of agriculture, access to credit is regarded as a fundamental enabler for growth and modernization. Through financial support, farmers are better positioned to engage in developmental initiatives and adopt innovative agricultural technologies that would otherwise take a longer period to become widespread (Adewale, 2022). Credit, therefore, serves not only as a source of capital but also as a catalyst for agricultural transformation. Agricultural financing may take different forms, including the deferred provision of essential inputs and services such as improved seeds, fertilizers, mechanized equipment (e.g., tractors), labor, and storage infrastructure. These supports are typically structured to align with the unique cash flow patterns of agricultural production (Adewale, 2022). Farm credit, as such, encompasses a variety of financial instruments tailored for the agricultural sector, including loans, promissory notes, bankers' acceptances, and bills of exchange. The timing and design of these instruments are influenced by the seasonality of farming activities, particularly the planting, harvesting, and marketing cycles.

In Nigeria, the allocation of credit by commercial banks across different sectors involves the distribution of financial resources to key economic activities such as agriculture, mining and quarrying, manufacturing, real estate, construction, and forestry and fisheries (Abdulmajeed, 2021). As part of efforts aimed at promoting economic diversification, the agricultural sector has increasingly been identified as a viable avenue for achieving food security and long-term sustainable development. By 2018, agriculture had accounted for approximately 25.1% of Nigeria's Gross Domestic Product (GDP), underscoring its significance in the nation's economic structure (Abdulmajeed et al., 2023). The agricultural industry in Nigeria is characterized by substantial growth potential and untapped opportunities. For instance, data published by the Nigerian Export Promotion Council (NEPC) in 2021 estimated that the market potential for Nigerian cocoa bean exports to ten leading international destinations including Germany, Malaysia, Turkey, Japan, and the Netherlands stood at roughly $425 million.

In response to the opportunities available within the agricultural sector, the Nigeria Digital Agriculture Strategy (NDAS) was formulated to provide a strategic framework for the digital transformation of agricultural processes. The initiative aims to create an integrated digital platform that would facilitate collaboration among a wide range of stakeholders, including government agencies, farmers, researchers, marketers, investors, and technology developers, with the goal of enhancing productivity and innovation within the sector (NITD, 2020). In this study, bank credit to agriculture is represented by the total volume of credit made available by deposit money banks to support agricultural activities. This comprises loans, advances, overdrafts, and various credit instruments collectively disbursed to actors within the agricultural sector. These financial commitments are measured in billions of Naira, serving as a proxy for institutional support to agricultural development in Nigeria.

2.2 Theoretical Review

2.2.1 Theory of Financial Innovations

The financial innovation theory, originally advanced by Silber (1983), emphasizes that developments within the financial sector are driven by the motivation to overcome institutional and economic constraints, which ultimately encourage the creation of innovative financial solutions. These innovations are regarded as mechanisms through which financial inclusion is deepened and access to financial services is broadened. According to this theory, external impediments

or regulatory challenges often prompt firms to pursue inventive strategies aimed at enhancing revenue streams and improving operational efficiency (Li & Zeng, 2010). Financial innovation, under this framework, may arise either through entirely novel initiatives or through the modification of existing mechanisms designed to strengthen a firm's liquidity position and adapt to evolving market conditions (Ionescu, 2012). Central to this theory is the notion that advancements in financial systems have a direct, favorable impact on economic growth. They are believed to stimulate the adoption of modern production techniques, sharpen firms' competitive capabilities, yield higher returns, and facilitate the overall expansion of the national economy through the application of technological innovations.

Moreover, the theory highlights the role of market inefficiencies and information asymmetries in generating high transaction and operational costs, which are viewed as primary catalysts for the emergence of financial innovations (Błach, 2011). It is also argued that innovation enhances the liquidity of financial markets by promoting the optimal reallocation of capital to sectors facing resource shortages and by illuminating investment opportunities for potential participants (Błach, 2011). Recent developments, particularly in digital finance, have been identified as instrumental in addressing long-standing gaps in financial access across developing economies. Mobile technologies and other digital service platforms are being deployed to promote the adoption of financial instruments that were previously underutilized (Omwansa & Waema, 2014). In this context, commercial banks are seen as facilitators, encouraging individuals to accumulate wealth and engage in financial planning over time.

Ultimately, the theory of financial innovation underscores the integration of digital delivery channels such as mobile banking, internet banking, automated teller machines (ATMs), and point-of-sale (POS) terminals into the financial ecosystem as a means to expand the availability and accessibility of financial services to a wider segment of the population.

2.2.2 Technology Acceptance Model

The Technology Acceptance Model (TAM), originally introduced by Davis in 1986, was developed to address the underlying factors that influence the adoption of emerging technologies (Monyoncho, 2015). Central to this model is the recognition that an individual's intention to use a technological system is largely shaped by behavioral tendencies and perceptions of the system's utility and user-friendliness. According to the theory, the perceived ease of use and perceived usefulness of a technological tool significantly determine its acceptance among users (Lim & Ting, 2012). These two variables are regarded as crucial predictors of whether a system will be adopted. Over time, the model has been expanded to explore how shifts in individual attitudes ultimately lead to behavioral changes concerning technology utilization (Lule et al., 2012).

Furthermore, the TAM framework seeks to explain the psychological processes that influence whether users embrace or reject a specific innovation, particularly when such technologies are introduced as improvements. The model emphasizes that the decision to adopt or reject a system stems from cognitive evaluations of its relevance and practicality. In both individual and organizational contexts, TAM serves as a predictive and evaluative instrument for anticipating how likely a new technological solution will be accepted (Mojtahed et al., 2011). In recent years, the model has been extensively applied to interpret user engagement with digital financial services, offering insights into the behavioral dynamics that accompany the transition to digital platforms.

In essence, the TAM framework provides a theoretical basis for understanding behavioral shifts among users in response to digital financial innovations. It clarifies how perceived value and user-friendliness can either facilitate or hinder the adoption of financial technologies, especially in environments where such innovations are gaining prominence.

2.3 Empirical Review

A growing body of empirical research has investigated the implications of digital finance across various economic dimensions in Africa, particularly Nigeria and various countries. However, a critical synthesis reveals both converging and diverging findings.

Babarinde et al. (2024) analyzed the relationship between digital financial transactions and stock market performance in Nigeria, focusing on the period between January 2012 and December 2021. Employing the Fully Modified Ordinary Least Squares (FMOLS) approach, the study measured the influence of four digital channels Automated Teller Machines (ATMs), Point of Sale (POS) terminals, mobile payments, and web-based payments on the stock market capitalization ratio. Data sourced from the Central Bank of Nigeria indicated that all four digital finance tools exerted a statistically significant and positive influence on stock market capitalization, suggesting that digital finance mechanisms can serve as enablers of capital market growth. Contrastingly, the study by Babarinde (2023), which used quarterly data from 2009 to 2019 and applied Vector Autoregression (VAR), Pearson correlation, and variance decomposition techniques, found no long-term causality between digital financial services and credit allocation by deposit money banks. Despite identifying a strong and positive short-term correlation, the study noted that digital finance failed to produce statistically significant effects on credit distribution, particularly in the case of POS transactions, which had a negative yet non-significant outcome. ATM and web-based payments, while positive in direction, also lacked statistical significance in affecting credit allocation. This suggests that while digital finance may influence perceptions or access metrics, its direct impact on credit distribution remains limited without structural reinforcement.

Menza et al. (2024) contributed to the discourse from an East African perspective by examining the role of Fintech in promoting financial inclusion in Ethiopia. Using panel data from nine commercial banks between 2015 and 2020, and a random effects model validated through the Hausman test, the study confirmed that digital tools such as ATMs, mobile banking, POS systems, and agent banking significantly enhanced financial inclusion. These findings reinforce the assertion that digital finance technologies play a critical role in democratizing access to financial services, especially in underbanked regions. In a related but tangential domain, Okijie and Effiong (2024) explored the challenges confronting entrepreneurial development within Nigeria's micro, small, and medium-sized enterprise (MSME) sector. Though not strictly focused on digital finance, the study underlined financial constraints, infrastructural deficits, and policy

instability as critical impediments to business growth. Recommendations centered on revisiting the 1999 United Nations framework for enterprise development and establishing coordinated capacity-building initiatives to bolster MSME performance. This indirectly suggests that digital financial services could be more impactful if integrated within broader institutional support mechanisms for entrepreneurs.

Agbaeze et al. (2023) conducted a longitudinal investigation into the relationship between digital financial services and agribusiness performance in Nigeria from 2001 to 2020. Utilizing an ex-post facto research design and applying the Auto-Regressive Distributed Lag (ARDL) model, with several econometric diagnostic tests, the study revealed heterogeneous outcomes. While mobile money and POS transactions were found to enhance agribusiness activity, the use of ATMs was associated with adverse effects on the sector. This suggests that not all digital payment infrastructures are equally effective in supporting agricultural enterprises. Complementing this narrative, Otitoju et al. (2023) reviewed the landscape of financial inclusion strategies in Nigeria, particularly as they relate to smallholder farmers. Their findings indicate that existing financial inclusion frameworks inadequately cater to the realities of smallholders. Barriers such as insufficient infrastructure, weak credit assessment frameworks, and low levels of financial and digital literacy were identified as persistent constraints. The study underscores the need for the development of customized financial products and delivery channels targeted at the smallholder demographic to ensure inclusive financial integration.

From a broader macroeconomic lens, Ren et al. (2023) examined the comparative effects of digital versus traditional financial inclusion on enterprise innovation in China. Using a custom-built index to distinguish between both forms of inclusion, the study found that digital financial inclusion positively influences innovation output, whereas traditional financial inclusion appears to inhibit it. Notably, both forms were found to constrain innovation efficiency. These results highlight the importance of refining digital financial systems to optimize enterprise innovation while acknowledging the differentiated impacts based on enterprise size and ownership structure. Similarly, Amar et al. (2023) assessed how digital financial inclusion (DFI) affects the operational ease of microenterprises. Through Analysis of Variance (ANOVA) and logistic regression, it was demonstrated that DFI mitigates regulatory and market access obstacles for microenterprises. Moreover, access to internet infrastructure, entrepreneurial experience, and educational attainment emerged as key predictors of successful DFI engagement. These findings point to the role of human and infrastructural capital in facilitating meaningful adoption of digital financial services at the micro-business level.

In a distinct context, Dhiaf et al. (2022) explored the relationship between FinTech adherence to manufacturing efficiency principles and market performance during the Fourth Industrial Revolution. Using a large panel dataset of U.S.-based firms over a decade (2010–2019), the study found that FinTech companies outperformed non-FinTech counterparts in manufacturing efficiency, which translated into superior market performance. These outcomes provide valuable insights for stakeholders in understanding how technological integration enhances operational and financial metrics. Contrasting with the above studies, Adewale et al. (2022) focused on the link between agricultural credit and productivity in Nigeria using data spanning from 1981 to 2016. Their OLS regression analysis indicated that while bank credit showed a positive and significant relationship with agricultural productivity, neither foreign exchange rates nor other financial variables demonstrated significant influence. The findings suggest that credit remains a vital input in enhancing agricultural output, though its efficacy may be moderated by macroeconomic conditions.

Chukwu et al. (2022) assessed how various digital banking platforms influenced the operational performance of commercial banks in Nigeria during the period from 2010 to 2019. By employing the Autoregressive Distributed Lag (ARDL) model, the study investigated the long-run and short-run dynamics between return on assets (ROA) and transaction volumes from POS devices, web-based banking, and USSD platforms. Data were sourced from CBN and NDIC publications. Despite the adoption of these digital channels, the results indicated a positive yet statistically insignificant association between digital banking and banks' ROA. This suggests that although digital tools are being utilized, their efficiency in enhancing bank profitability remains limited within the observed timeframe. In contrast, Onyeiwu et al. (2021) focused on small and medium-sized enterprise (SME) financing and its macroeconomic impact in Nigeria between 1999 and 2018. Utilizing Ordinary Least Squares (OLS) regression, the study discovered that neither credit to SMEs nor gross capital formation had the anticipated stimulative effect on GDP, with lending rates exerting a contractionary influence by reducing GDP by 7%. Unexpectedly, the only variable with a notable positive impact was electricity distribution, which raised GDP by 4.6%. These outcomes challenge traditional assumptions about the growth-inducing capacity of SME credit and suggest that structural issues may undermine the effectiveness of such financial support in Nigeria.

Expanding the lens to Europe, Pakhnenko et al. (2021) proposed a comprehensive framework for assessing the digitalization of financial services (DFSI), incorporating elements of digital inclusion, financial inclusion, and digital service access. Using a composite index formed through the weighted sum of eight indicators assigned weights via the Fishburne method—the study categorized 30 European countries into four tiers of digital finance development. Countries such as Denmark, the Netherlands, and the UK led with high DFSI scores, while Eastern European nations like Romania and Bulgaria were ranked critically low. The middle spectrum included nations such as Germany, France, and Spain. This stratification highlights the uneven advancement of digital finance across Europe and provides a basis for policy benchmarking and regional strategy development. A global perspective was offered by Ozili (2020), who examined patterns of digital finance adoption in four countries namely, the US, UK, Nigeria, and India using data from the Global Financial Development database. The study found that the US and UK had higher levels of digital finance usage compared to Nigeria and India, though nuanced differences were observed: the US led in credit card adoption, whereas the UK showed stronger debit card usage. Interestingly, Nigeria demonstrated greater debit card penetration than India, despite its lower overall digital finance usage. Moreover, high debit card usage in both the US and Nigeria was associated with increased

private sector credit, whereas high credit card usage in the UK correlated negatively with private sector credit and remittance flows. These patterns suggest that the form of digital finance adopted significantly affects broader financial sector dynamics.

In the context of the West African Economic and Monetary Union (WAEMU), the contribution of mobile technology and internet access to expanding financial inclusion was assessed by Senou et al. (2019). Utilizing data from the Central Bank of West African States and the International Telecommunication Union spanning 2006 to 2017, the researchers examined the individual and combined effects of mobile phone usage and internet connectivity. While each technology was found to support financial inclusion independently, the simultaneous application of both tools was identified as particularly effective. The analysis led to a policy recommendation that emphasizes not only technological availability but also accessibility, affordability, and the necessity of regulatory flexibility for mobile financial service providers. These findings suggest that a coordinated digital infrastructure policy could yield greater inclusion outcomes than fragmented efforts. In contrast, Shen et al. (2019) explored the mediating mechanisms through which digital tools influence financial inclusion in China. Applying Partial Least Squares (PLS) within a Structural Equation Modeling (SEM) framework, the study disentangled the roles of internet usage, financial literacy, and digital financial product adoption. Contrary to intuitive assumptions, internet access alone was found to exert no direct influence on financial inclusion. Instead, it served as a facilitator that enhanced financial literacy and promoted the use of digital financial services—factors that were directly linked to greater inclusion. The findings underscore the importance of human capital development, particularly in terms of financial education, as a prerequisite for the success of digital finance initiatives. The study concludes with a call for policymakers to strengthen digital literacy programs and foster engagement with digital financial products to realize broader inclusion goals.

Shifting focus to agricultural finance in Nigeria, Olowofeso et al. (2017) employed a Nonlinear Autoregressive Distributed Lag (NARDL) model to examine how fluctuations in credit to the agricultural sector influenced output growth between 1992 and 2015. Although short-run asymmetries in the credit-output relationship were not evident, the long-run analysis revealed differentiated effects. Specifically, positive changes in credit to agriculture were associated with substantial increases in agricultural output, albeit with a delayed effect typically materializing after four quarters. This finding points to the temporal lag in the productivity response to financial interventions, emphasizing the need for sustained credit flow and policy patience in the sector.

Synthesizing the above studies, it becomes evident that digital finance's effects are neither uniformly positive nor immediate. While infrastructure and usage have improved in some regions, the functional benefits, such as enhanced profitability or GDP growth, are often constrained by broader institutional and structural factors. Moreover, the comparative insights from Europe and other global economies reveal the critical importance of contextual tailoring in digital finance policy, infrastructure deployment, and user engagement strategies. There remains a pressing need for developing economies to refine their digital ecosystems, improve financial literacy, and strengthen infrastructure to ensure that digital financial tools yield their intended economic benefits. When considered collectively, these studies offer a layered understanding of the digital and financial levers available for inclusive development. The digital divide whether in infrastructure, usage, or literacy emerges as a critical constraint, not merely in terms of access but also in terms of how these technologies are integrated into productive and financial systems. Moreover, the temporal dimension, as shown in the agricultural finance case, reinforces the importance of long-term strategies and monitoring to evaluate the effectiveness of financial inclusion policies. Rather than viewing digital access or credit availability as stand-alone solutions, these findings advocate for a more holistic, systemic approach that combines financial education, regulatory support, and institutional commitment to foster sustainable inclusion.

3. METHODOLOGY

The objective of this research was to evaluate how digital financial transactions specifically Automated Teller Machine (ATM) usage, Point of Sale (POS) operations, and web-based payments have influenced credit distribution to the agricultural sector by Deposit Money Banks (DMBs) in Nigeria. Emphasis was placed on identifying the extent to which these three indicators of digital finance contribute to the allocation of credit within the agricultural domain. Quarterly secondary data, spanning from 2009Q1 to 2021Q4 and comprising a total of 48 observations, were employed for empirical analysis. The dataset was sourced from publicly available financial statistics and reports. In line with an ex-post facto research design, the investigation relied on historical records to discern patterns and relationships between digital financial activities and agricultural lending.

To ensure robustness in methodological approach, a suite of econometric techniques was utilized. These included the Augmented Dickey-Fuller (ADF) unit root test to check for stationarity, the Johansen co-integration test to assess the long-run relationship among variables, and the Granger causality test to explore predictive causality. Furthermore, advanced estimation techniques such as Dynamic Ordinary Least Squares (DOLS), Canonical Co-integrating Regression (CCR), and Fully Modified Ordinary Least Squares (FMOLS) were applied to produce reliable long-term coefficients. The analytical framework adopted in this study aligns with the model proposed by Babarinde (2023), who examined digital finance's role in the credit allocation processes of Nigerian banks. However, this study extends the methodological rigor by incorporating more contemporary and statistically robust techniques namely, FMOLS, DOLS, and CCR to provide enhanced insight into the dynamics at play. In conclusion, the study was anchored in the exploration of how technology-driven financial services have altered the distribution patterns of agricultural credit in Nigeria. By drawing on empirical evidence and utilizing comprehensive econometric tools, the research offers valuable insight into the digitalization of financial services and its implications for agricultural financing by DMBs.

The general equation of the regression model for this study is stated in equation (1) thus:

$$AGRICFIN_t = \beta_o + \beta_1 ATM_t + \beta_2 POS_t + \beta_3 W - PY_t + \mu_t \quad (1)$$

Where:

AGRICFIN = Agricultural Financing; ATM = automated teller machine; POS= point-of-sales; W-Pay = web/online banking

Moreover, the pairwise Granger causality test was employed to consider the direction of causality between digital financial service and Bank credit to Agricultural sector in Nigeria. The pairwise Granger causality test equations are stated equations 2 to 5:

$$\text{AGRICFIN}_t = +\sum_{t=1}^{n} ATM_{t-i} + \sum_{t=1}^{n} \text{POS}_{t-j} + + \sum_{t=1}^{n} \text{W} - \text{PY}_{t-k} + Ut_1 \quad (2)$$

$$\text{ATM}_t = +\sum_{t=1}^{n} \text{AGRICFIN}_{t-i} + \sum_{t=1}^{n} \text{POS}_{t-j} + + \sum_{t=1}^{n} \text{W} - \text{PY}_{t-k} + Ut_1 \quad (3)$$

$$\text{POS}_t = +\sum_{t=1}^{n} \text{AGRICFIN}_{t-i} + \sum_{t=1}^{n} \text{ATM}_{t-j} + + \sum_{t=1}^{n} \text{W} - \text{PY}_{t-k} + Ut_1 \quad (4)$$

$$\text{W-PY}_t = +\sum_{t=1}^{n} \text{AGRICFIN}_{t-i} + \sum_{t=1}^{n} \text{ATM}_{t-j} + + \sum_{t=1}^{n} \text{POS}_{t-k} + Ut_1 \quad (5)$$

4. Empirical Results

4.1 Descriptive Statistics

Table 1. Descriptive Statistics

	AGRICFIN	ATM	POS	W_PAY
Mean	490.5475	1408.652	733.9463	13232.16
Median	473.4500	933.9550	176.8300	34.39000
Maximum	1457.820	5469.487	6423.603	120273.2
Minimum	88.63510	62.59000	1.870000	3.370000
Std. Dev.	313.0388	1537.546	1404.066	32023.91
Skewness	1.118845	1.527796	2.870668	2.133351
Kurtosis	3.961931	4.232843	10.46321	5.967519
Jarque-Bera	12.85390	23.52251	192.1020	58.52364
Probability	0.001617	0.000008	0.000000	0.000000
Observations	52	52	52	52

Source: Authors' computation using E-views 10, (2024).

As presented in Table 1, the analysis of the descriptive statistics indicates that, on average, quarterly figures for AGRICFIN, ATM, POS, and W-PAY transactions amounted to approximately ₦490.55 billion, ₦1,408.65 billion, ₦733.95 billion, and ₦13,232.16 billion respectively across the observed period. A comparison between standard deviations and mean values reveals that all variables except AGRICFIN exhibit substantial variability, suggesting significant deviations from their respective averages. In contrast, AGRICFIN displays a relatively lower degree of dispersion, implying greater stability in its values over time. Skewness coefficients for all the variables indicate a positive skew, suggesting a distribution with a longer right tail and the presence of values that exceed the mean more frequently than those below it. This reflects a pattern where observations are concentrated on the lower end of the scale. Regarding kurtosis, all variables are identified as leptokurtic, indicating a distribution with heavier tails and sharper peaks compared to the normal distribution. This suggests the presence of outliers or extreme values more frequently than would be expected under a standard normal distribution. Furthermore, the Jarque-Bera test statistics returned significant values for all the variables, with p-values falling below the 5% threshold. This result leads to the rejection of the null hypothesis of normality, implying that none of the data series follows a normal distribution during the period under review.

4.2 Unit Root Tests

The Augmented Dickey Fuller (ADF) unit root test's results are summarized in Table 2.

Table 2. Augmented Dickey-Fuller Test Statistics

	t-Statistic	**Prob.**	**Remarks**	**t-Statistic**	**Prob.**	**Remarks**	I(d)
AGRICFIN	4.654743	1.0000	Not Sta.	-3.955648	0.0034	Sta.	I(1)
ATM	1.896311	0.9997	Not Sta.	-10.66554	0.0000	Sta.	I(1)
POS	0.990579	0.9959	Not Sta.	-5.753284	0.0000	Sta.	I(1)
WEBPAY	-1.302559	0.6216	Not Sta.	-9.239889	0.0000	Sta.	I(1)

Source: Authors' computation using E-views 10, (2024).

To assess the time series properties of the data, the Augmented Dickey-Fuller (ADF) unit root test was employed. The outcomes, as detailed in Table 4.2, reveal that the individual series for AGRICFIN, ATM, POS, and W-PAY were initially found to be non-stationary at their levels, indicating the presence of unit roots. However, after applying first differencing to each of the series, stationarity was achieved across all variables. This result implies that each data series is integrated of order one, denoted as I (1), thereby confirming that they exhibit stochastic trends which were corrected through differencing.

4.3 Co-integration Test

Table 3. Johansen Co-integration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.566572	69.93519	47.85613	0.0001
At most 1	0.326366	28.13375	29.79707	0.0768
At most 2	0.085245	8.380363	15.49471	0.4257
At most 3 *	0.075506	3.925416	3.841466	0.0476

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**

None *	0.566572	41.80144	27.58434	0.0004
At most 1	0.326366	19.75339	21.13162	0.0770
At most 2	0.085245	4.454947	14.26460	0.8085
At most 3 *	0.075506	3.925416	3.841466	0.0476

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Source: Authors' computation using E-views 10, (2024).

To investigate the presence of a long-term equilibrium relationship among the variables, the Johansen-Juselius co-integration approach was employed. The results derived from both the Trace statistic and the Maximum Eigenvalue statistic indicate that no statistically significant co-integrating relationship exists between digital financial transaction indicators and credit disbursement by deposit money banks to the agricultural sector at the 5% significance threshold. This outcome suggests that, over the examined period, digital financial activities and agricultural credit allocation by banks did not move together in a stable long-run relationship within the Nigerian context.

4.4 Regression Results

Table 4. Regression Results

	Canonical Co-integrating Regression (CCR)		**Dynamic Least Squares (DOLS)**		**Fully Modified Least Squares (FMOLS)**	
	Dependent Variable: AGRICFIN					
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
ATM	0.211665	0.0000	0.184807	0.0000	0.211985	0.0000
POS	0.068490	0.0060	0.207629	0.0002	0.067034	0.0041
W_PAY	-0.003477	0.0249*	-0.004968	0.0021*	-0.003466	0.0231*
C	190.3079	0.0000	187.4740	0.0000	190.2277	0.0000
R-squared	0.893738		0.963604		0.894033	
Adj. R-sq	0.886955		0.951472		0.887269	
Jarq-Bera	0.631130		0.410369		0.488818	
Prob.	072937		0.81449		0.78316	
	7		7		7	

Source: Authors' computation using E-views 10, (2024).

The cointegration outcomes between digital financial indicators and the credit disbursement to the agricultural sector by Deposit Money Banks (DMBs) in Nigeria are presented in Table 4.4. Employing the Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), and Canonical Cointegrating Regression (CCR) methods, the findings revealed that transactions conducted via Automated Teller Machines (ATMs) and Point-of-Sale (POS) terminals exhibited a statistically significant and positive influence on the volume of agricultural credit allocated. In contrast, web-based payment systems demonstrated a significant but inverse relationship with credit flow to the sector. Furthermore, the explanatory power of the models, as reflected by their respective R-squared (R^2) values 89% for FMOLS, 96% for DOLS, and 89% for CCR suggests a high level of explanatory adequacy. These results imply that the selected digital financial transaction variables collectively account for a substantial proportion of the observed variation in the credit allocation behavior of Nigerian DMBs toward the agricultural sector.

4.5 Pairwise Granger Causality Tests

Table 5. Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
ATM does not Granger Cause AGRICFIN	51	3.53630	0.0661
AGRICFIN does not Granger Cause ATM		15.7827	0.0002
POS does not Granger Cause AGRICFIN	51	6.66626	0.0129
AGRICFIN does not Granger Cause POS		9.99327	0.0027
W_PAY does not Granger Cause AGRICFIN	51	1.52081	0.2235
AGRICFIN does not Granger Cause W_PAY		7.31470	0.0094
POS does not Granger Cause ATM	51	6.75367	0.0124
ATM does not Granger Cause POS		8.92930	0.0044
W_PAY does not Granger Cause ATM	51	1.67394	0.2019
ATM does not Granger Cause W_PAY		5.07038	0.0290
W_PAY does not Granger Cause POS	51	17.5033	0.0001
POS does not Granger Cause W_PAY		3.39379	0.0716

Source: Authors' computation using E-views 10, (2024).

As outlined in Table 4.5, the pairwise Granger causality analysis demonstrated the presence of a mutual causal relationship between Automated Teller Machine (ATM) transactions and credit allocation to the agricultural sector in

Nigeria. A similar bi-directional causality was identified between Point-of-Sale (POS) transactions and agricultural credit distribution. Conversely, a unidirectional causality was observed in the case of web-based payment transactions, where causation flowed solely from agricultural credit towards web-pay usage, indicating that changes in agricultural lending significantly influenced the volume of web-pay financial activities within the studied period.

5. Conclusion and Recommendations

This study conducted an empirical analysis to evaluate the influence of digital financial transaction channels on the allocation of credit to the agricultural sector by Deposit Money Banks (DMBs) in Nigeria. Digital finance was represented through three main indicators: Point-of-Sale (POS) transactions, Automated Teller Machine (ATM) transactions, and web-based payment systems, while agricultural credit was measured by the volume of credit extended to the agricultural sector by DMBs. Quarterly data spanning from the first quarter of 2009 to the fourth quarter of 2021 was utilized. A series of robust econometric techniques namely the Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), Canonical Cointegrating Regression (CCR), and Pairwise Granger Causality tests were applied to examine both the direction and nature of the relationship among the variables. Prior to estimation, the Augmented Dickey-Fuller (ADF) unit root test revealed that all-time series variables were non-stationary at level but attained stationarity after first differencing, confirming their integration of order one.

Further analysis using the Johansen co-integration framework indicated the existence of a long-term relationship between digital financial transaction indicators and credit disbursement to agriculture by banks. The results from the FMOLS, DOLS, and CCR estimations consistently demonstrated that ATM and POS transactions had a statistically significant and positive influence on credit flows to the agricultural sector. In contrast, web-based payment transactions were found to exert a statistically significant but negative effect on credit allocation to agriculture. Based on these findings, it can be inferred that ATM and POS transaction mechanisms play a facilitative role in enhancing the distribution of credit to the agricultural sector by commercial banks in Nigeria. Consequently, the study recommends that stakeholders in the agricultural sector adopt digital financial tools to improve their access to financial resources. Furthermore, DMBs are encouraged to increase the deployment of ATM and POS infrastructure, especially in rural areas where agricultural activities are predominantly located, to further stimulate financial inclusion and sectoral credit expansion. The policy direction should shift from a generalized push for digital finance adoption to a sector-specific, inclusion-oriented digital financial ecosystem that targets the peculiar needs of Nigeria's diverse farming communities. By institutionalizing these measures, DMBs and farmers alike can harness the full potential of digital financial innovation to catalyze agricultural productivity and rural development.

While this study has provided valuable insights into the influence of digital financial transactions on the allocation of credit to agriculture by Deposit Money Banks (DMBs) in Nigeria, several limitations present opportunities for future research. Firstly, the analysis was conducted at an aggregate national level, which may obscure regional variations in digital finance adoption and credit access. Given Nigeria's socio-economic diversity, future studies should consider disaggregating the data by geopolitical zones or states to capture regional heterogeneity in both digital infrastructure availability and agricultural financing outcomes. Methodologically, while the use of robust cointegration and causality tests strengthens the validity of the findings, panel data approaches or spatial econometric models may offer additional insights into dynamic and localized patterns of credit distribution influenced by digital finance. Finally, qualitative studies incorporating farmer-level perspectives could complement quantitative findings by uncovering behavioral, cultural, and institutional factors influencing the uptake of digital finance and its impact on agricultural credit.

References

Abdulmajeed, T. I., (2021). A causality link between inflation rate and deposit money bank total sectoral credit allocation in the presence of structural breaks in Nigeria. Online Journal of Arts, Management and Social Sciences (OJAMSS), 5(2), 18 – 35.

Abdulmajeed, T. I., Mairafi, S. L., & Abdullahi, Y. U. (2023). Monetary policy and commercial banks' credit to agricultural sector: a study of Nigeria. UMYU Journal of Accounting and Finance Research, 5(1), 84 – 96. doi: https://doi.org/10.61143/umyu-jafr.

Adewale, A. T., Lawal, O. A., Aberu, .F., & Toriola, A. K. (2022). Effect of Credit to Farmers and Agricultural Productivity in Nigeria. East Asian Journal of Multidisciplinary Research (EAJMR), 1(3), 377-388. doi: https://doi.org/10.55927

Agbaeze, C. C., Ezechi, C. P. D. & Okechukwu, I. C. (2023). Impact of Digital Finance on Agricbusiness Development in Nigeria. Journal of Risk and Financial Studies. 4(1), 107-133. doi: https://doi:10.47509/JRFS.2023.v04i01.06

Amar J., Asif, M., Tarka, M., Rahisha, W. K., & Wasiq, M. (2023). Digital financial inclusion in micro enterprises: understanding the determinants and impact on ease of doing business from World Bank survey. Humanities and Social Sciences Communications, 1(1) 1-10. doi: https://doi.org/doi.org/10.1057/s41599-024-02856-2

Babarinde G. F. (2023) Impact of Digital Finance on Banks' Credit Allocation in Nigeria. Journal of Public Administration, Finance and Law, 29(1), 69-80.

Babarinde, G. F., Onyejiaku, C. C., Obadire, A. M., Pridy, A. A., & Onwumere, J. U. J. (2024) Impact of digital finance on stock market performance in Nigeria (2012M1-2021M12). Intern. Journal of Profess. Bus. Review, 9(3), 01-34. doi: https://doi.org/10.26668

Błach, J. (2011). Financial Innovations and their Role in the Modern Financial System –Identification and Systematization of the Problem. Financial Internet Quarterly -e-Finanse, 7(3), 13-26.

Central Bank of Nigeria (2018). National financial inclusion strategy (revised).

Central Bank of Nigeria (2022). Statistical bulletin.

Chukwu, K. O. & Molokwu, S.R. (2022) Effects of Digital Banking on the Performance of Commercial Banks in Nigeria 2010 -2019. International journal of multidisciplinary research and analysis 5(1), 133-148, doi: https://doi.org/10.47191/ijmra/v5-i1-18

Davis, F. D. (1986). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 319-340. doi: https://doi.org/10.2307/249008.

Dhiaf, M. M., Khakan, N., Atayah, O. F., Marashdeh, H. & El Khoury, R. (2022). The role of FinTech for manufacturing efficiency and financial performance: in the era of industry 4.0, Journal of Decision Systems. doi: https://doi.org/10.1080/12460125.2022.2094527

Fapetu, O., & Obalade, A. A. (2015). Sectoral allocation of banks' credit and economic growth in Nigeria. International Journal of Academic Research in

Business and Social Sciences, 5(6), 161-169. doi: http://dx.doi.org/10.6007/IJARBSS/v5-i6/1666

Ionescu, C. (2012). Financial Instability and Financial Innovations. Economy Transdisciplinarity Cognition, 15(2), 30-37.

Li, X. & Zeng, S. (2010). Finance Innovation Model Literature Review. Beijing University of Technology.

Lim, W. M. & Ting, D. H. (2012). E-shopping: An Analysis of the Technology Acceptance Model. Modern Applied Science, 6(4), 49 -62.

Lule, I., Omwansa, T. K. & Waema, T. M. (2012). Application of Technology Acceptance Model (TAM) in M-Banking Adoption in Kenya. International Journal of Computing and ICT Research, 6(1), 31-43.

Manyika, J., Lund, S., Singer, M., White, O., & Berry, C. (2016). Digital Finance for All: Powering Inclusive Growth in Emerging Economies. McKinsey Global Institute, September, 1–15.

Menza, M., Jerene, W., & Oumer, M. (2024). The effect of financial technology on financial inclusion in Ethiopia during the digital economy era. Cogent Social Sciences, 10(1). doi: https://doi.org/10.1080/23311886.

Mojtahed, R., Nunes, J. M. B. & Peng, G. C. (2011). The Role of the Technology Acceptance Model in Information Systems Research. In Proceedings of the International Workshop on Information Systems Research Trends, Approaches and Methodologies Rome, Italy.

Monyoncho. L. N. (2015). Relationship between Banking Technologies and Financial Performance of Commercial Banks in Kenya. International Journal of Economics, Commerce and Management, 3(11), 784 -815.

National Information and Technology Development [NITD], (2020). Nigeria Digital Agriculture Strategy (2020-2030), 1-47.

Okijie S. R. & and Effiong, U. E. (2024) Financing and Successful Micro, Small and Medium Scale Enterprise Development in Nigeria. East African Finance Journal (EAFJ), 3(1) 1 – 26. doi: https://doi.org/10.59413/eafj/v3.i1.1

Olowofeso, o. E., Adeboye, A. A., Adejo, V. T., Bassey, K. J., & Abraham, O. (2017). Agricultural Sector Credit and Output Relationship in Nigeria: Evidence from Nonlinear ARDL. CBN Journal of Applied Statistics, 8(1), 101-122.

Omwansa, T. K. & Waema, T. M. (2014). Deepening Financial Inclusion through Collaboration to Create Innovative and Appropriate Financial Products for the Poor. Working Paper, 1(14).

Onyeiwu, C., Muoneke, O. B. & Nkoyo, U. (2021). Financing of small and medium scale enterprises and its growth impact in Nigeria. The Journal of Entrepreneurial Finance, 22(2). doi: https://doi.org/10.57229/2373-1761.1385

Onyia, C. C. (2019). Impact of commercial bank sectoral credit allocation to the real sector on the output growth of Nigerian economy. IDOSR Journal of Arts and Humanities, 4(1), 100-110.

Otitoju, M. A., Adelere, O. E., A.O. Akinbola, A. O., & Abah, E. G. (2023). Implications of Digital Financial Inclusion for Smallholder Farmers in Nigeria: A Review. International Journal of Social Science and Humanities Research, 11(3), 152-157. doi: https://doi.org/10.5281/zenodo.8276200

Ozili, P.K. (2018). Impact of Digital Finance on Financial Inclusion and Stability. Borsa Istanbul Review, 18(4), 329-340.

Ozili, Peterson K. (2020). Comparing digital finance in the UK, US, India and Nigeria. Financial Internet Quarterly, Sciendo, Warsaw, 16(4), 1-11. doi: https://doi.org/10.2478/fiqf-2020-0023

Pakhnenko, O., Rubanov, P., Hacar, D., Yatsenko, V., & Vida, I. (2021). Digitalization of financial services in European countries: Evaluation and comparative analysis. Journal of International Studies, 14(2), 267-282. doi: https://doi.org/10.14254/2071-8330.

Ren K., Wang Y., & Lulu L. (2023) Impact of Traditional and Digital Financial Inclusion on Enterprise Innovation: Evidence from China. SAGE Open 1–19. doi: https://doi.org/10.1177/21582440221148097

Senou, M. M., Ouattara, W. & Houensou, D. A. (2019). Financial inclusion dynamics in WAEMU: Was digital technology the missing piece? Cogent Economics & Finance, 7(1), 1665432. doi: https://doi.org/10.1080/23322039.

Shekhar, A., Mohanty, B., Sarkar, S. (2023). Digitalization effect of financial inclusion in banking. Academy of Marketing Studies Journal, 27(4), 1-10.

Shen, Y., Hueng, C. J., Hu, W. (2019). Digital Technology to Improve Financial Inclusion in China. Article in applied Economics Letters, 1(1), 16-29. doi: https://doi.org/10.1080/13504851.2019.1606401

Silber, W. L. (1983). The process of financial innovation. The American Economic Review, 73(2), 89-95.