The Impact of Digital Financial Services on Banking Stability Under the Moderating role of Financial Inclusion: Evidence from Egypt

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Abstract

This study investigates Egypt's banking sector, focusing on the impact of digital financial services (DFS) on banking stability under the moderating role of financial inclusion amid the debate between "innovation-growth" and "innovation-fragility," perspectives. Using balanced panel data from 30 Egyptian banks spanning 2011–2022 and employing hierarchical regression analysis and cross-sectional analysis, the study finds that DFSs play a crucial role in promoting financial inclusion. Moreover, financial inclusion significantly moderates banking stability, as evidenced by using non-performing loans or capital adequacy proxies. Therefore, the Egyptian context supports "innovation-growth" by demonstrating that DFSs directly support financial inclusion and indirectly contribute to banking stability. Further research can solidify our understanding of these relationships and guide policymakers in crafting effective strategies for a more inclusive and stable financial system.

Keywords

Digital Financial Services; DFS; Banking Stability; Financial Inclusion; Egypt.

Article history

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1. Introduction

Digital Financial Services (DFSs) are a wide variety of financial services that are accessible and provided via digital channels. The technology in financial services has spread to phone banking, app banking, internet banking, e-wallets, ATMs (Automated Teller Machines), POS (Point of Sale), credit and debit cards, etc. The service offers several advantages to customers, such as ease and seamless financial transactions. (Ozili, 2018; Obiora and Ozili, 2023). The emergence of DFSs has transformed the financial landscape in many countries (Demirguc-Kunt et al., 2018). These services are allowing millions of people who do not have access to traditional banking services or have limited access to such services the opportunity to use financial services for the first time. Egypt represents an important case study for the impact of digital financial services, as the country has seen rapid growth in this sector over the past three decades.

The banking sector has undergone significant digitalization, particularly after the onset of the COVID-19 epidemic under DFSs (Fu and Mishra, 2022; Dluhopolskyi et al., 2023). Although the inevitability of digitization and the need for digital transactions have been acknowledged (Yao, 2020), there is little understanding of their economic and financial consequences. Based on the prior literature, limited studies investigate the effects of digitalization, or more broadly, financial technology, on banking services and the stability of this industry which revealed that digital payment can enhance financial inclusion, stimulate economic activity, and contribute to GDP growth (Hasan et al., 2012; Beck et al., 2016; Ozili, 2018; Demirguc-Kunt et al., 2018; Goldstein et al., 2019; Kamal and Souparnika, 2021; Rastogi et al., 2021; Wagdi and Tarek, 2022; Zhang et al., 2019a).

Financial inclusion refers to the accessibility and availability of basic financial services to all members of the population. It ensures that individuals and businesses have access to useful and affordable financial products and services in a responsible and sustainable manner. Theories of financial inclusion provide frameworks for understanding the factors that hinder or promote access to financial services, as well as the potential impacts of such access on individuals and broader economies. The proliferation of DFS is transforming the banking landscape in emerging markets. These innovative services promote financial inclusion by providing affordable and convenient access to financial services for underserved populations (Telukdarie and Mungar, 2023).

The theoretical framework for financial inclusion includes many theories, including theories of financial inclusion beneficiaries Theories of financial inclusion delivery and their implications for policy and practice. There are multiple perspectives on who gains from the results of financial inclusion. Some studies demonstrate that financial inclusion benefits poor people (de Sant'Anna and Figueiredo, 2024), while others argue that women are the main beneficiaries of financial inclusion outcomes (Swamy, 2014; Ghosh and Vinod, 2017). Additionally, others believe that the economy and the financial system benefit from financial inclusion (Kim et al., 2018; Swamy, 2014; Ozili, 2018).

In addition to women and individuals with low income, other overlooked potential beneficiaries of financial inclusion include young people, elderly individuals, institutionalized individuals, people with disabilities, and those who have been excluded from the financial sector due to criminal activities. Various perspectives exist regarding the entities responsible for offering formal financial services to the public. Some believe that private entities, such as banks and financial technology companies, can provide formal financial services to consumers more effectively (Ozili, 2018). These assumptions about the necessity of agents to provide formal financial services require a rationale to understand their importance in delivering such services.

The Egyptian banking sector has witnessed great interest from academics, as most of them dealt with the financial aspect of financial efficiency (Kamel et al., 2021); profitability (JREISAT and BAWAZIR, 2021; Abdou and Alarabi, 2024); social responsibility (Osman et al., 2021; Shahwan and Habib, 2023) or financial inclusion (Rashdan and Eissa, 2020; ElDeeb et al., 2021); while the marketing aspect dealt with digital financial services (Mostafa, 2020; Hassan and Wood, 2020). On the other hand, there is a scarcity of studies focusing on banking stability, regardless it is influenced by internal governance (Marie et al., 2021).

The relationship between digital financial services (DFS) and banking stability is multifaceted. The "innovation-growth" and "innovation-fragility" perspectives offer contrasting views on these impact benefits (Beck et al., 2016, de Sant'Anna and Figueiredo, 2024). Financial inclusion is theorized to play a moderating role, either mitigating risks and improving the efficiency of the financial system (Allen and Gale, 1994; lul, 1995; Grinblatt and Longstaff, 2000; Houston et al., 2010; Wang et al., 2021A; Domeher et al., 2022) or amplifying risks (Brunnermeier, 2009; Fung et al., 2020).

The remainder of this paper is organized as follows. Section 2 discusses the Theoretical Rooting and Literature Review. Section 3 describes the Study Methodology and Design, Section 4 reports Data Analysis and Results and chapter 5 concludes.

2. Theoretical Rooting and Literature Review

The convergence of banking stability, digital financial services (DFS), and financial inclusion forms a crucial junction in today's world of finance. To identify research gaps, this section delves into these connections, looking at how digital financial services affect banking stability under financial inclusion.

2.1. Banking Stability

Banking stability refers to the ability of the banking system to withstand shocks and disruptions without compromising its core functions of financial intermediation and payment settlement (Gulaliyev et al., 2019). Usually, before the 2008 global financial crisis, the evaluation of financial indicators such as "the capital adequacy ratio," "asset quality," "profitability," "liquidity," and "market risk sensitivity" is conducted according to the standards of the CAMELS methodology. This methodology is employed to assess the financial condition of banks (Dincer et al., 2011; Aspal and Dhawan, 2016). A stable banking system is essential for economic growth and development as it facilitates efficient allocation of resources, promotes investment, and supports financial inclusion (Ozili, 2020). Conversely, banking instability can have severe consequences for the economy, leading to financial crises, economic recessions, and social unrest.

Several methods and indicators are used to assess banking stability, each capturing different aspects of the financial health and resilience of banks and the banking system as a whole. Some of the most commonly used measures include:

2.1.1. Capital Adequacy Ratio (CAR): The CAR measures the adequacy of a bank's capital relative to its risk-weighted assets. It reflects the bank's ability to absorb losses and maintain solvency in the face of adverse shocks. A higher CAR indicates a stronger capital base and greater resilience to risk. Studies by Abou-El-Sood (2016), Ryan (2017), Hadjixenophontos and Christodoulou-Volo (2018), Saputra et al. (2020), Al-Rjoub (2021), and Nguyen (2021) have highlighted the importance of CAR as a key indicator of bank stability, demonstrating its predictive power for bank failures and financial crises.

2.1.2. Non-Performing Loan (NPL) Ratio: The NPL ratio measures the proportion of a bank's loan portfolio that is classified as non-performing, meaning the borrower has defaulted on payments or is unlikely to repay the loan in full. A high NPL ratio indicates poor asset quality and potential losses for the bank, which can erode its capital base and threaten its stability. Numerous studies, including Jiang et al., (2018), Tatarici et al. (2020), Bacchiocchi et al. (2022), and Katuka et al., (2023) have established a strong link between rising NPL ratios and banking instability, particularly during periods of economic stress.

2.1.3. Return on Assets (ROA): The ROA measures a bank's profitability relative to its total assets. It reflects the efficiency of the bank's operations and its ability to generate income from its assets. While not a direct measure of stability, a higher ROA can contribute to stability by enhancing the bank's capacity to build capital buffers and absorb losses. For instance, Kanapiyanova et al. (2023) have explored the relationship between bank profitability and stability, highlighting the importance of maintaining adequate profitability levels for ensuring long-term stability.

2.1.4. Liquidity Ratios: Liquidity ratios assess a bank's ability to meet its short-term obligations. Common liquidity ratios include the current ratio and the quick ratio, which compare a bank's liquid assets to its short-term liabilities. Adequate liquidity is crucial for maintaining confidence in the banking system and preventing bank runs. Studies by Chiaramonte and Casu (2017); Amara and Mabrouki (2019) have examined the role of liquidity risk in banking crises, emphasizing the importance of sound liquidity management for ensuring financial stability.

2.1.5. Systemic Risk Measures: These measures assess the interconnectedness and potential for contagion within the banking system. Examples include the marginal expected shortfall (MES) and the systemic expected shortfall (SES), which estimate

the potential losses a bank may face in the event of a systemic financial crisis. According to Ellis et al. (2014); Varotto and Zhao (2018), systemic risk measures has been explored as a means of assessing and mitigating financial stability risks.

2.1.6. Z-score: These measures are used in banking to assess the stability and solvency of banks. It is calculated based on a combination of factors that reflect a bank's capitalization, profitability, and risk. Prior research by (Chiaramonte et al., 2015; Ghassan and Guendouz, 2019; Tarkocin and Donduran, 2023) has used Z-score as an indicator of banking stability. application Z-score.

Additionally, González and Keddad (2024) propose a new liquidity and capital adequacy risk index, the Piggy Bank Index. This index measures the gap between liquid assets and total liabilities over liquid capital. Collectively, numerous empirical studies have contributed to the measurement of bank stability using various proxies.

On the other hand, banking stability is positively correlated with increases in the growth rate and foreign direct investment (FDI). Conversely, banking instability is associated with rises in the interest rate, depreciation of the exchange rate, high levels of inflation (Neifar and Gharbi, 2023), economic policy uncertainty (Syed, 2024), and corruption on banks' credit levels (Ali, 2022; Jungo et al., 2023) as well as on the nation level (Alshubiri et al., 2023).

Notably, there is no single measure that can fully capture the complexities of banking stability. Therefore, a comprehensive assessment typically involves using a combination of indicators and considering both quantitative factors like the level of market concentration (Herwald et al., 2024; Mateev et al., 2024), the growth rate, FDI, the interest rate, the exchange rate, and the inflation rate (Neifar and Gharbi, 2023). In addition to qualitative factors like country risk (Athari et al., 2023) and cyclical behavior (Bouheni and Hasnaoui, 2017), conflicts may occur in the relationships between the independent variables and measures of banking stability for the same sample. According to Chinoda and Kapingura (2023), digital financial inclusion has a significant positive relationship with bank stability based on z-score and a negative relationship with non-performing loans. Thus, regulatory authorities must be careful when making decisions that may result in an increase in market power and the creation of systemic banks, as this could reduce banking stability (El Moussawi et al., 2024), especially under higher levels of market concentration (Herwald et al., 2024).

2.2. Digital Financial Services

Financial inclusion, defined as the access and usage of formal financial services by all members of society, has long been a developmental goal. The advent of digital financial services has significantly altered the landscape, offering new opportunities to bridge the financial inclusion gap in emerging markets. The ubiquity of mobile phones and the internet has facilitated innovative solutions that transcend traditional barriers, enabling individuals to engage in financial activities more conveniently and securely (Demirguc-Kunt et al., 2018). There are many studies that dealt with digital banking services, including services such as Internet banking (Alarifi and Husain, 2023; Hameed and Nigam, 2023; Ong and Chong, 2023); mobile banking (Ong and Chong, 2023; Inan et al., 2023; Khan et al., 2023); POS (Point of Sale) (Ogbonne, 2023; Phan et al., 2023); credit and debit banking cards (Astuty, 2023); ATM (automated teller machine) (Sarveswararao et al., 2023; Alabdulatif ET AL., 2023); and e-wallet (Selsapagita and Sukardi, 2023; Kilani ET AL., 2023).

In Egypt, several types of digital financial services (DFS) have been introduced to cater to the financial needs of the population, especially considering the growing access to technology and mobile connectivity. Some of the prominent DFS in Egypt include:

2.2.1 E-wallet: E-wallet allow users to conduct various financial transactions using their mobile phones. In Egypt, services like Vodafone Cash, Etisalat's Floos, and Orange Money enable users to send and receive money, pay bills, top up mobile credit, and sometimes access other financial services like savings or microloans.

2.2.2 Digital Payments: Digital payment solutions and e-wallets are gaining popularity, facilitating online and offline transactions. For instance, Fawry is a widely used payment service in Egypt that enables users to pay bills, purchase goods and services, and even transfer money digitally.

2.2.3 Online Banking: Traditional banks and financial institutions in Egypt offer online banking services that allow customers to manage their accounts, transfer funds, pay bills, and access other financial products through web or mobile applications.

2.2.4 Digital Microfinance Services: Several initiatives aim to provide microfinance digitally, offering small loans and financial services to entrepreneurs and individuals who might not have access to traditional banking.

These DFS in Egypt are contributing to financial inclusion by providing convenient, accessible, and often more affordable financial services, especially to segments of the population that were previously underserved or excluded from the formal financial system.

A crucial aspect of the impact of digital financial services is the role played by technological innovations. Mobile money platforms, fintech solutions, and blockchain technologies have emerged as powerful tools, revolutionizing the financial services sector in emerging markets. These innovations have the potential to create scalable and cost-effective solutions, making financial services accessible to a broader segment of the population (Allen et al., 2014).

Microfinance institutions have increasingly embraced digital financial services as a means to amplify their impact. By leveraging technology, microfinance institutions can efficiently reach a larger clientele, disburse loans, and collect repayments, thereby enhancing their ability to serve the financial needs of individuals in the informal sector (CGAP, 2019). While digital financial services present immense opportunities, challenges such as cybersecurity, data privacy, and technological literacy persist. Addressing these challenges is imperative to sustain and maximize the positive impact of digital financial services on financial inclusion in emerging markets. Moreover, future research should focus on refining strategies to ensure the inclusivity and sustainability of digital financial services (Chang et al., 2020; Ediagbonya and Tioluwani, 2023).

2.3. Financial Inclusion

Aduda and Kalunda (2012) concluded that products that identify financial inclusion must be provided. Access and usage must be included in financial inclusion measures since access and usage are not the same but supplementary. Ozili (2018) found that digital finance affects financial inclusion in advancing the economy. It facilitates the transfer of different incomes to financial services, but at a lower cost than that submitted to them by official banks. This will improve financial inclusion and, in turn, financial stability. Anarfo et al. (2020) found that financial inclusion is negatively affected by tight financial regulation. The requirements of capital adequacy negatively affect the ability of banks to submit financial services, but financial stability can oppose this negative effect. There is a positive relationship between competition in the financial inclusion on financial stability through the control variable GDP and a negative effect through inflation.

However, Lenka and Bairwa (2016) found that there is a significant impact of financial inclusion on monetary policy. Since there is a negative relationship between inflation and financial inclusion, it will lead to a constant price level in the economy. Although financial inclusion causes an increase in GDP in all cases, its effect on inequality differs. Dabla-Norris et al. (2015) The effect on the Gini coefficient can be positive or negative for a reduction in credit participation costs, based on the countryspecific characteristics. For example, Uganda's GDP reacts more if the increase in credit-to-investment ratio results from reduced participation costs. However, Egypt's GDP responds more to relaxing the borrowing constraint, while other countries are more reactive to lower financial intermediation costs. David et al. (2018) found a significant positive relationship between financial inclusion determinants and GDP per capita income, broad money, credit to the private sector, and the number of internet users, as an increased amount of money in circulation will properly enhance financial inclusion in the country. In addition, the internet has fundamentally abridged the cost of transactions through the use of mobile devices and ATMs. It has increased the capacity for credit delivery in remote areas of the country.

Iqbal and Sami (2017) found that the GDP of the country is positively affected by the number of bank branches and the credit deposit ratio of banks, which are indicators of financial inclusion. As another indicator of financial inclusion, ATMs growth rate has shown an insignificant impact on Indian GDP. Accordingly, financial inclusion is greatly accompanied by the progress and development of the economy. Kim et al. (2018) found that economic growth in OIC countries is positively affected by financial inclusion. Oz-Yalaman (2019) concluded that financial inclusion, as a means of reducing poverty and enhancing welfare, is also considered one of the reasons behind increasing tax revenues. Shen et al. (2021) found that digital financial inclusion has a great positive effect on economic growth at the 1% level. The improvement of digital financial inclusion in a country can upgrade its economic growth. Digital financial inclusion has an overflow effect on neighboring countries. Singh and Stakic (2021) found that in the long run, there was a small positive effect of financial inclusion on GDP per capita, and it increase in banking facilities and activities will lead to increased economic growth because banks are the main financial intermediaries between savers and corporations, or small and medium enterprises. Nizam et al. (2020) and van et al. (2021) concluded that there is a limitless effect on the relationship between financial inclusiveness and economic growth. Such an effect is stronger for countries with lower growth than for countries with higher growth.

2.4. The relation between financial inclusion and digital financial services

Financial inclusion, which refers to the accessibility and utilization of formal financial services by all individuals in the economy, stands as a crucial focal point on the global policy agenda for sustainable development. In particular, insufficient levels of financial inclusion serve as a significant impediment to economic growth and, consequently, sustainable development. According to de Sant'Anna and Figueiredo (2024), fintech innovation brings unbanked segments into the financial system.

Consequently, financial inclusion is regarded as a cornerstone of sustainable development. This inclusive financial system forms the basis for comprehensive long-term economic growth, job creation, facilitation of fundraising for small enterprises, preservation of financial and social stability, and the attainment of national objectives, as suggested by (Beck et al. 2007).

As a result, the promotion of enhanced financial inclusion emerges as a pressing challenge for developing nations. This urgency arises from the fact that over 90% of individuals without access to or use of formal financial services, commonly known as the unbanked population, are situated in developing countries (Demirguc-Kunt et al., 2018). Hence, financial inclusion is not merely crucial but is established as a primary objective for all developing nations to prioritize.

Digital finance services and financial inclusion offer numerous advantages to users of financial services, providers of digital finance, governments, and the overall economy. The G-20 and the World Bank have spearheaded efforts since 2010 to enhance financial inclusion in developing nations, aiming to alleviate poverty levels in these regions (Ozili, 2018).

Access to digital technologies has enabled a wider array of financial services, including online banking, mobile banking, e-wallets, mobile wallets, credit, and debit cards. These technologies bring about various benefits, such as convenience and easy financial transactions for customers. However, amidst the evolution of the economy, the looming threat of cyberattacks remains a significant concern.

Despite the growing comfort of cashless payments, certain negative perceptions persist, hindering the widespread adoption of these systems. Concerns revolve around issues like security problems, inadequate network coverage, reluctance among merchants to embrace digital payment methods, high transactional costs, and users' lack of familiarity with technology. These perceptions act as barriers, deterring many individuals from fully embracing the new cashless payment systems.

According to Domeher et al., (2022), financial inclusion has impact on the relationship between innovation and economic growth and recommended that governments invest in the appropriate technological infrastructure that the banking sector can leverage to enhance the provision of banking services, which is key to promoting financial inclusion and economic growth.

Lenka and Barik (2018) found that the expansion of mobile phones and internet services will positively affect financial inclusion. While the level of unemployment and the size of the ruler population negatively affect financial inclusion, the level of income and education are positively affected by financial inclusion. Mushtaq and Bruneau (2019) used financial inclusion as a channel to assess how poverty is affected by information and communication technology. Furthermore, it is found that there is a negative relationship between microfinance intensity, information and communication indicators, poverty, and the poverty gap. Improving the information and communication technology infrastructure will positively affect financial inclusion, which in turn will improve mobile banking. Karsdóttir et al. (2019) found that the speed and strength of financial inclusion are greatly affected by the big data available on mobile phones, as the attitude of people towards using phones is considered an important source of data to determine whether they should be granted a loan or not. Thus, the study proposed that the data has to be used positively to make financial inclusion easier for people who don't have enough information about correct profiling. Ozili (2021a) concluded that artificial intelligence and big data develop the efficiency and risk management processes of financial services providers. It leads to easier provision of smart financial products and services to banked adults and simplifies the account opening process for unbanked adults.

In Egypt, the government has launched the Sustainable Development Strategy (SDS): Egypt's Vision 2030, emphasizing financial inclusion as a top national priority and a central objective within the overall sustainable development strategy. However, achieving high levels of financial inclusion, like in many developing countries, presents significant challenges. As of 2017, the World Bank's Global Findex database indicated that only 33% of Egypt's adult population possessed a bank account, a notably lower percentage compared to other developing nations. Barriers perceived by the unbanked people include insufficient funds to open a bank account, distance, being too expensive to open a bank account, and a lack important official documentation as the main barriers that prevent them from accessing and using formal financial services.

2.5. The relation between digital financial services and Banking Stability

Extensive research has documented the positive impact of DFS on financial inclusion. Particularly, mobile money has been instrumental in expanding access to financial services in developing countries. Studies have shown that mobile money adoption leads to increased savings, improved access to credit, and enhanced financial resilience among previously excluded populations (Jack & Suri, 2014; Mbiti & Weil, 2017).

Previous research has shown that digital financial services facilitate financial intermediation by means of outreach initiatives (Ozili, 2018). The main catalyst for the exponential expansion of digital financial services is their cost-effectiveness, extensive accessibility, and enhanced security measures, on the one hand. The banking sector in many of the emerging markets is struggling with low banking profitability and increasing nonperforming loan (NPL) problems (Syed & Tripathi, 2019). Together, with the low profitability and high NPLs, banks in emerging countries are also struggling to maintain their outreach of digital financial services on par with those in developed countries (Syed et al., 2022).

According to Wang et al. (2020), digital finance assists in improving financial efficiency in China. The influence is more in the eastern region compared to the northern region of China, but Zhang et al. (2019b) conclude that peer-to-peer lending replaces bank loans, and that higher P2P lending negatively influences bad loans.

According to Kelikume (2021), penetration of digital financial services improves financial inclusion and reduces the informal economy. However, Risman et al. (2021) confirm that digital finance improves financial inclusion but also hampers financial sector instability. In addition, Wang et al. (2021b) argue that the rise of fintech has led to improved risk control for banks, hence contributing to the stability of the financial system. Moreover, Daud et al. (2022) examined the impact of fintech on financial stability, specifically focusing on the influence of competition and concentration and concluded a favorable and substantial correlation between fintech and financial stability.

Additionally, Ketterer (2017) concludes that digital financial services enhance outreach activities, but weak regulation, low connectivity, and security issues pose risks in the short run. However, Carbó-Valverde (2017) reveals that digital finance helps reduce marginal costs and increases productivity; however, it also poses various privacy, regulatory, and safety challenges. According to Sodokin et al. (2022), the beneficial and important effects of digital transformation as a general-purpose technology on financial inclusion are evident. The impact of digital transformation on financial inclusion is significantly greater when the banking system is stable.

However, the impact of DFS on banking stability is a relatively new area of research with limited empirical evidence. Some studies suggest that DFS can enhance stability by improving risk management practices, increasing competition, and promoting financial innovation (Ozili, 2018). Although, concerns remain regarding the

potential for DFS to increase systemic risk and exacerbate financial instability due to the increased complexity and interconnectedness of the financial system (FSB, 2017).

2.6. The relation between Financial Inclusion and Banking Stability

The relationship between financial inclusion and banking stability is complex and multifaceted. On the one hand, greater financial inclusion can enhance stability by diversifying the financial system's funding base, reducing information asymmetries, and promoting responsible financial behavior (Han & Melecky, 2013). On the other hand, rapid and uncontrolled expansion of financial inclusion may pose risks to stability, particularly if it leads to excessive credit growth or the emergence of new and unregulated financial products (Morgan & Pontines, 2014).

According to Beck et al. (2016) and de Sant'Anna and Figueiredo (2024), the viewpoints of "innovation-growth" and "innovation-fragility" propose that financial innovation may either have a beneficial or detrimental effect on financial systems. The conventional perspective on innovation and growth suggests that financial innovations enhance the operations of the financial system by enabling risk sharing (Allen and Gale, 1994), filling market gaps (Elul, 1995; Grinblatt and Longstaff, 2000), enhancing allocative efficiency (Houston et al., 2010), and improving the quality of financial services (Wang et al., 2021a). Conversely, the "innovation-fragility" perspective suggests that financial advancements, such as fintech and bigtech, have the potential to heighten risks by intensifying the spread of negative effects, reinforcing economic cycles, and increasing market instability. This could ultimately lead to a financial crisis, similar to the subprime crisis of 2008 (Brunnermeier, 2009; Fung et al., 2020).

3. Study Methodology and Design

3.1. Research Gap

The global financial landscape is undergoing a significant transformation driven by the rapid advancement of digital technologies. This digital revolution has given rise to a new era of financial services, commonly referred to as digital financial services (DFS). DFS encompasses a wide range of financial products and services, including mobile money, online banking, digital payments, and peer-to-peer lending platforms, that leverage digital technologies to enhance the accessibility, convenience, and affordability of financial services (Arner, Barberis, & Buckley, 2017).

Egypt, like many other developing countries, recognizes the potential of DFS to drive financial inclusion and economic growth. The Egyptian government has actively promoted DFS adoption through various initiatives and policies, such as the National Financial Inclusion Strategy (NFIS) launched in 2014 (Central Bank of Egypt, 2014). The NFIS aims to increase access to financial services for underserved and unbanked populations, particularly women, youth, and those living in rural areas.

While the potential benefits of DFS are widely acknowledged, concerns remain regarding its impact on financial stability. The increased complexity and

interconnectedness of the financial system due to DFS may introduce new risks and vulnerabilities, such as cybersecurity threats, operational risks, and potential for financial exclusion (Claessens et al., 2018). Therefore, understanding the relationship between DFS, financial inclusion, and banking stability is crucial for harnessing the benefits of DFS while mitigating potential risks.

This study seeks to address this gap in knowledge by examining the impact of DFS on banking stability in Egypt, with a particular focus on the mediating role of financial inclusion. We hypothesize that DFS positively influences banking stability by promoting financial inclusion, which in turn strengthens the financial system's resilience and stability.

3.2. Study Problem and Questions

Limited studies have examined the impact of DFSs on the stability of financial and banking systems in both international and emerging countries, besides, it has been recommended investigating this association (Danisman and Tarazi, 2020; Goldstein et al., 2019).

The current study investigates this association and adds a new variable, which is financial inclusion. Previous studies found that DFSs, as an independent variable, has a significant impact on financial inclusion. Moreover, banking stability, as a dependent variable, is affected by financial inclusion rates, which in turn moderates this association. However, there is an ongoing theoretical debate about the implications of digital financial services on banking stability primarily based on two contrasting theories: the 'innovation-growth' and 'innovation-fragility' viewpoints. Given the debate, the present study aims to bridge the research gap within the Egyptian banking sector by determining which of these theories is more applicable. To achieve this, the study seeks to address the following research questions:

Q1: Is there impact of digital financial services on financial inclusion in Egypt?

- Q2: Does financial inclusion's moderating role contribute to the interpretation of the impact of digital financial services on nonperforming loans in Egypt?
- Q3: Does financial inclusion's moderating role contribute to the interpretation of the impact of digital financial services on capital adequacy in Egypt?

3.3. Study Aim and Objectives

The study aims to understand the dynamic relationship between three variables, namely digital banking services, financial inclusion, and banking stability, by addressing the following objectives:

3.3.1 Analysis of digital financial services in Egypt: The primary objective of this study is to conduct a thorough analysis of digital financial services in Egypt, examining the utilization and impact of phone banking, internet banking, mobile banking, POS transactions, credit and debit banking cards, and ATMs in the banking sector.

3.3.2 Measuring banking stability in Egypt: The objective of this study is to develop a comprehensive framework for measuring banking stability in Egypt, encompassing key indicators such as nonperforming loans (NPL) and the capital adequacy of banks, to assess the resilience and stability of the banking sector within the Egyptian financial landscape.

3.3.3 Investigating the impact of digital financial services on banking stability under financial inclusion: This study seeks to investigate the impact of digital financial services on banking stability in Egypt, with a specific focus on how financial inclusion, measured by the percentage of bank accounts, mediates this relationship, thus providing insights into the interplay between digital financial services, financial inclusion, and banking stability.

3.4. Study Hypotheses

To answer research questions, research hypotheses are stated as follows:

- H1: There is a significant impact of digital financial services on financial inclusion in Egypt.
- H2: There is a significant impact of digital financial services on nonperforming loans in Egypt because of the moderating role of financial inclusion.
- H3: There is a significant impact of digital financial services on the capital adequacy of banks under the moderating role of financial inclusion in Egypt.

3.5. Study Population

The Arab Republic of Egypt tests the study's hypotheses. Egypt's banking sector has undergone significant changes in recent years, with the government implementing reforms to modernize the industry in addition to the National Financial Inclusion Strategy (NFIS). These initiatives have led to increased competition and the introduction of new financial products and services. As a result, the sector has experienced steady growth and has become an integral part of Egypt's economy. Furthermore, the adoption of digital banking technologies has enhanced accessibility and convenience for customers, leading to a more efficient and customer-friendly banking experience. Overall, the future looks promising for the banking sector as it continues to evolve and adapt to meet the changing needs of its clients and the global market (Bolbol et al., 2005; Poshakwale and Qian, 2011).

The government's commitment to creating a conducive regulatory environment and promoting sustainable banking practices has further strengthened Egypt's banking sector. With a focus on responsible finance and environmental sustainability, banks in Egypt are aligning their operations with global best practices, which not only benefits the environment but also enhances the sector's reputation and credibility (Helmy and Wagdi, 2019). In Egypt, the banking landscape presents a fascinating interplay between Islamic, conventional, and specialized banks. Islamic bank's function based on Islamic law (Sharia), but conventional bank operates on the principles of interest-based lending and borrowing. Additions to specialized bank may have additional regulatory considerations depending on their area of focus. For instance, an agricultural bank might work closely with the Ministry of Agriculture. All banks operate under the supervision of the Central Bank of Egypt (CBE), adhering to regulations that ensure financial stability and transparency. However, Islamic banks also adhere to Sharia compliance regulations set by their internal Sharia boards and external auditing bodies. According to the Central Bank of Egypt until the end of 2022, the number of registered banks was 36 banks.

3.6. Study sample

The study hypotheses are examined within in the Arab Republic of Egypt over the period from 2011 to 2022, utilizing a sample of 30 bank; as presented d in Table No. (1).

No.	Banks	Registration Date	No.	Banks	Registration Date
1	Banque Misr	18/1/1958	16	AL Ahli Bank of Kuwait – Egypt	29/6/1978
2	National Bank of Egypt	1/1/1961	17	First Abu Dhabi Bank – Misr	29/8/1978
3	Egyptian Arab Land Bank	18/1/1958	18	Faisal Islamic Bank of Egypt	14/6/1979
4	Agricultural Bank of Egypt	11/8/1977	19	Housing and Development Bank	24/9/1979
5	Banque Du Caire	18/1/1958	20	Al Baraka Bank of Egypt S.A.E.	8/5/1980
6	The United Bank	25/6/2006	21	National Bank of Kuwait - Egypt (NBK)	26/5/1980
7	Bank of Alexandria	18/1/1958	22	Abu Dhabi Islamic Bank – Egypt	24/7/1980
8	Misr Iran Development Bank (MIDBank S.A. E)	26/6/1975	23	ABU DHABI COMMERCIAL BANK EGYPT	15/10/1981
9	Commercial International Bank (Egypt)	13/8/1975	24	Egyptian Gulf Bank	28/1/1982
10	Attijariwafa bank Egypt S.A.E	13/8/1975	25	Arab African International Bank	10/6/1982
11	Societe Arabe Internationale de Banque	9/9/1976	26	HSBC Bank Egypt S.A.E	15/7/1982
12	Credit Agricole Egypt S.A.E	12/5/1977	27	Arab Banking Corporation–Egypt S.A. E	25/11/1982
13	Emirates National Bank of Dubai S.A.E.	14/7/1977	28	Export Development Bank of Egypt	31/12/1984
14	Suez Canal Bank	9/3/1978	29	Arab International Bank	5/6/2012
15	Qatar National Bank Alahli S.A.E	13/4/1978	30	Arab Bank PLC	10/6/1976

Table No. (1): Study sample

Source: The authors prepared the table based on CBE's data.

According to the available data, the sample size is 30 representing 83.33% of the study population. Figure (1) illustrates the distribution of the sample components according to the bank style.



Source: The authors prepared the figure based on CBE's data. **Fig. No. (1): Distribution of Sample Components by Bank Type**

According to figure No. (1); conventional banks constitute the largest propotion of the sample, accounting for 76.67%, while specialized banks and Islamic banks represent 13.33% and 10% respectively.

3.7. Study Variables

The study includes three types of variables: digital financial services; banking stability and financial inclusion. Mediators and moderators are variables that affect the association between an independent variable and an outcome variable. Mediators provide additional information about how or why two variables are strongly associated. In contrast, moderators explain the circumstances that cause a weak or ambiguous association between two variables that were expected to have a strong relationship. Mediators and moderators are often overlooked in research designs, or the terms are used incorrectly. Both mediator and moderator variables are important tools for researchers to understand the relationships between different factors. (Bennett, 2000).

The relationship between digital financial services (DFS) and banking stability is multifaceted. The "innovation-growth" and "innovation-fragility" perspectives offer contrasting views on this impact. Financial inclusion is theorized to play a moderating role, potentially mitigating risks, or amplifying benefits (Beck et al., 2016, Anarfo and Abor (2020), de Sant'Anna and Figueiredo, 2024). Thus, the study includes three types of variables: independent variables and dependent variables, addition to moderate variable; As shown in Figure No (2).



Moderate variable

Fig. No. (2): Study variables

The current study cannot use Fitch's Banking Stability Indicator (BSI), which assesses the state of banking stability across countries. is the BSI is a composite measure of banking system quality that ranks countries by five levels of banking system quality ("very high" (A), "high" (B), "acceptable" (C), "low" (D), and "very low" (E). Since this study focuses on a single country, the BSI is not applicable, although the authors maintain its applicability to cross-sectional data from multiple countries.

The current study collects financial stability data based on non-performing loans and capital adequacy, excluding the rate of return on assets, liquidity rates, systemic risks, and Z-score. This can be justified as follows: The first (ROA) is a measure of profitability and not banking stability, despite the fact that the sustainability of profitability is one of the pillars of banking stability. The second (liquidity rates) is only a measure of short-term banking risks. The third (systemic risk) did not have full data available in the Egyptian banking sector. Finally, the fourth (Z-score) does not have general acceptance for application in banks, as is the case for companies.

Numerous economic and non-economic factors affect banking stability (Ali, 2022; Alshubiri et al., 2023; Jungo et al., 2023; Neifar and Gharbi, 2023; Herwald et al., 2024; Mateev et al., 2024; and Syed, 2024), however, these factors will not be examined in this study because they are more relevant for cross-sectional data analysis. Instead, the current study focuses on one country, the Arabic Republic of Egypt.

According to the Central Bank of Egypt (CBE), banks have shown interest in offering electronic banking services to keep up with technological advancements in the industry. These services may include both traditional and innovative banking services delivered over electronic communication networks, as well as the issuing of electronic payment instruments for conducting transactions. In order to mitigate the risks faced by banks, the Central Bank of Egypt is revising the laws and norms governing unlicensed service providers in the local banking market. The bank is doing this to align with recent changes in the area and uphold its commitment to safeguarding the market. The activities involved in providing financial services are as follows:

a. Banking services via internet banking.

- b. Payment services via electronic wallets and automated teller machines (ATMs).
- c. Internet banking services through smartphones (through downloaded apps it calls mobile banking too).
- d. Banking services through automated teller machines (ATMs).
- e. Electronic payment card issuance services (debit, credit, prepaid, and contactless cards).
- f. Electronic collection services.

In accordance with the lack of data available for about all DFS at Egyptian Bank, the reliance was on three digital services variables, which appear as independent variables, are "POS"; "Credit and Debit Banking Cards"; and "ATM".

Table No. (2) Study variables

Study va	riables	Measurement				
		The logarithmic value of the number of points of sale (POS)				
Indonandant	Digital Financial Services	The logarithmic value of the number of bank cards (Credit and Debit				
Variables		Cards)				
		The logarithmic value of the number of Automated Teller Machines				
		(ATMs)				
Mediator	Financial	Percentege of heads accounts out of the total population over 15 years				
Variable	Inclusion	recentage of bank accounts out of the total population over 15 years				
Dependent	Banking	Ratio of non-performing loans to total loans				
Variables	Stability	Capital adequacy ratio				

Due to the limited data on e-wallets and mobile banking (call app banking too), they were excluded from the research variables. Therefore, the study recommends that researchers in future studies test the impact of electronic wallets and mobile banking in addition to other digital financial services.

3.8. Data Collection

This study utilizes a combination of secondary data sources and primary data collected through a financial report of Egyptian banks. Secondary data on financial inclusion is obtained from the Egyptian banks, the World Bank Global Findex database and the Central Bank of Egypt.

3.9. Study models

The study includes three models. The first model examines how digital financial services impact financial inclusion in Egypt. The second and third models, using financial inclusion as a moderate variable, test how digital financial services affect financial stability based on non-performing loans and capital adequacy.

 $FI_{TEgypt} = \beta_0 + \beta_{POS} POS_{TI} + \beta_{BC} BC_{TI} + \beta_{ATM} ATM_{TI} + \varepsilon_{TI}$

Equation No. (1)

 $NPL_{TI} = \beta_0 + \beta_{POS} POS_{TI} + \beta_{BC} BC_{TI} + \beta_{ATM} ATM_{TI} + \beta_{FI} FI_{TEgypt} + \epsilon_{TI}$

Equation No. (2)

 $CAR_{TI} = \beta_0 + \beta_{POS} POS_{TI} + \beta_{BC} BC_{TI} + \beta_{ATM} ATM_{TI} + \beta_{FI} FI_{TEgypt} + \epsilon_{TI}$

Equation No. (3)

The study tested three hypotheses, and Equations (1), (2) and (3) were drafted to test these hypotheses. Where (I) represent the bank and (T) represents time. (FI) represents the financial inclusion based on percentage of bank accounts out of the total population over 15 years, (POS) represents point of sale, (BC) represents credit and debit banking cards, and (ATM) represents Automated Teller Machines. In equation (2), (NPL) represents nonperforming Loan as a dependent variable, but in equation (3), (CAR) represents Capital adequacy of bank as a dependent variable. (β_0) denotes the constant term, while (ϵ_{TI}) represents the random error term.

3.10. Study Contribution

This study offers several contributions on both the practical and empirical levels. In terms of practical applications, the study sheds light on the development of digital financial services (DFS) and financial inclusion in Egypt. Furthermore, it provides empirical data on DFS growth and their usage among existing bank customers, aiming to optimize banking stability. Empirically, the study employs models to quantify the relationships between DFS adoption, financial inclusion levels, and banking stability indicators, potentially revealing both direct and indirect effects. Additionally, the study examines the moderating role of increased financial inclusion (achieved through DFS) on banking stability in the Egyptian context. Finally, by combining empirical findings with practical guidance, the study formulates policy recommendations for Egyptian regulators, promoting financial inclusion via digital services while ensuring banking sector stability.

4. Data analysis and Results 4.1. Stationary of Data

The assumption of stationery (constant variance) exists in many time series methods. One of the defining characteristics of a stationary process is that the mean, variance, and autocorrelation values do not vary over time; The study exam the data stationary to ensure that the mean and variance were invariant according to a unit root test, the stationarity of the time series of the basic independent and dependent indicators at level zero was evaluated according to the constant level. The study applied Augmented Dickey–Fuller (ADF), Philips–Perron (PP), Im, Pesaran and Shin W-stat (IPSW), Levin, Lin and Chut (LLC) tests and the data is stationary at a significance

level of less than 0.05. In addition to the Tau-statistic, the Z-statistic criteria were employed and reached data stationary at a significance level of less than 0.05.

4.2. Descriptive statistics4.2.1. Traditional and Digital Financial Services in Egypt

Egypt suffers from many problems with banking awareness, as well as a lack of skills in dealing with digital services. The number of branches increased by 28.69% during the period 2011–2022, from 3573 branches in 2011 to 4598 branches in 2022 (see figure No. 2). Therefore, the study found that there is great interest in traditional banking services.



On the other hand, there is great interest from the Central Bank of Egypt in providing digital financial services. The figures No. (3), (4), (5), and (6) shows the progress of these services during the period 2011–2022.



Fig. No. (3): Number of AMTs in Egypt 2011-2022

According to figure No. (3); the number of ATMs increased by 317.93% during the period 2011–2022, where the number of ATMs increased from 5258 ATMs in 2011 to 21975 ATMs in 2022. Figure No. (4), however, clearly illustrates the progress of bank cards.



Source: The authors prepared the figure based on CBE's reports. Fig. No. (4): Number of bank cards in Egypt 2011-2022

According to figure No. (4); the number of bank cards increased by 333.38% during the time period 2011-2022, where the number of bank cards increased from 12,931,992 bank cards in 2011 to 56,044,907 bank cards in 2022. but figure No. (5) illustrated the progress of POS.



According to figure no. (5), the number of POS increased by 472.54% during the period 2011–2022, from 32,911 POS in 2011 to 18,8429 POS in 2022. There is a discrepancy between traditional and digital financial services in terms of growth rates in the Egyptian banking sector. The data under investigation indicate high growth rates of digital services compared to the traditional branches of Egyptian banks, where point-of-sale services had the highest growth. Figure No. (6) shows that financial services growth rates were at the sector level during the period 2011–2022.



Source: The authors prepared the figure based on CBE's reports. **Fig. No. (6): traditional and digital financial services growth**

4.2.2. Financial Inclusion in Egypt

Financial inclusion is the term used to describe how simple it is for everyone to obtain and use financial services. Based on the percentage of financially included citizens (16 years and above), the study found increased significantly to 64.8% at the end of 2022, compared to 14% at the end of 2011, figures No. (7) illustrated the progress of financial inclusion in Egypt for this period.



Source: The authors prepared the figure based on both IMF's and CBE's reports. Fig. No. (7): Progress of Financial Inclusion in Egypt

According to figures No. (7); It reflects a growth rate of 362.8% during the period from 2011 to 2022, as per the Financial Inclusion Datahub Indicators at the Central Bank of Egypt.

4.2.3. Banking Stability in Egypt

The Egyptian banking sector, a cornerstone of the nation's economic landscape, has navigated a tumultuous period between 2011 and 2022. Political transitions and economic fluctuations have all presented challenges to financial stability. Within this context, the issue of non-performing loans (NPLs) and capital adequacy ratio emerges as a critical factor influencing the health and resilience of Egyptian banks.

The most important source of banking instability in Egypt was net foreign asset position (See Figure No. 8), at the end of December 2023, the banks' net foreign asset position reached an all-time high of -USD16.2bn. The decrease in foreign assets is a consequence of using some of the banks' foreign liquidity to assist the government and the Central Bank of Egypt (CBE), particularly after the departure of portfolio investors. Foreign portfolio investment (FPI) that preferred Egyptian debt instruments in addition to the Egyptian Stock Exchange, the US policy of raising interest rates, and risk aversion contributed to this matter.

As a result of shortage of net foreign asset position, banks have been compelled to limit the amount of US dollars that can be withdrawn, restrict credit card usage, and restrict the financing of imports, except for essential commodities. This has had a detrimental impact on the economy, leading to the growth of the informal market, increased inflation, and limitations on manufacturing activity. This indicates the state of instability that the Egyptian banking industry suffers from, which is due to irrational government spending. Addition to government and households borrowing from the domestic banks in Egypt led to over one-to-one crowding out of private business credit (Haikal et al., 2023).



Source: Macrobond, BMI Fig. No. (8): Net Foreign Liability Position – Egypt

Despite this, the CBE implemented a policy of maintaining a minimum CAR of 10% during the first and second phases of its banking sector reforms. However, the global financial crisis of 2008 impacted the sector, leading to a relatively low retum on assets (ROA) and return on equity (ROE) in 2009. The gradual implementation of Basel III norms, beginning in 2012, further affected these ratios. A key aspect of Basel III involved revising the CAR calculation method, necessitating additional capital provisioning. This initially led to a decline in CAR and ROE. However, from 2014 onwards, these metrics began to improve as the sector adjusted to the new regulatory framework. In 2020, the CBE enacted a legislative reform law aimed at achieving monetary and banking stability while fostering a more robust banking sector to support the nation's economic development goals. This reform complements the CBE's broader strategy of expanding its business scope and enhancing its institutional efficiency.

4.2.3.1. Banking Stability according to the non-performing loan

Figure No. (9) shows the non-performing loans ratio for the Egyptian banking sector during the period from 2011 to 2022, and it includes all Egyptian banks.



Source: The authors prepared the figure based on CBE's reports. **Fig. no. (9): Non-Performing loans ratio of Egyptian banking sector**

According to Figure No. 9, there is a downward trend in the non-performing loan ratio for the Egyptian banking sector, as the ratio was the highest in 2011 by (11%) compared to (3.3% in 2022.

4.2.3.2. Banking Stability according to the capital adequacy ratio

Figure No. (10) shows the capital adequacy ratio for the Egyptian banking sector during the period from 2011 to 2022.



Source: The authors prepared the figure based on CBE's reports. Fig. no. (10): Capital adequacy ratio of Egyptian banking sector

According to Figure No. (10), there floating the capital adequacy ratio for the Egyptian banking sector, as the highest capital adequacy rate in 2021 was at (22.2%) while the lowest rate was in 2014 at (13%).

4.2.4. Correlation between study variables

Table No. (2) shows the correlation coefficients between the study variables.

 Table No. (2): Correlation between study variables

		-					
		car	npl%	N. ATMs	N. Points of Sale	total cards	f. incluion
car	Pearson Correlation	1	252**	.379**	.376**	.369**	.392**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	<.001
	Ν	360	360	360	360	360	360
npl%	Pearson Correlation	252**	1	.315	.323**	.327**	033
	Sig. (2-tailed)	<.001		<.001	<.001	<.001	.527
	Ν	360	360	360	360	360	360
N. ATMs	Pearson Correlation	.379**	.315**	1	.960**	.970**	.912**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001	<.001
	Ν	360	360	360	360	360	360
N. Points of Sale	Pearson Correlation	.376**	.323**	.960**	1	.965**	.904**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001	<.001
	Ν	360	360	360	360	360	360
total cards	Pearson Correlation	.369**	.327**	.970**	.965**	1	.915**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		<.001
	Ν	360	360	360	360	360	360
f. incluion	Pearson Correlation	.392**	033	.912**	.904**	.915**	1
	Sig. (2-tailed)	<.001	.527	<.001	<.001	<.001	
	Ν	360	360	360	360	360	360

Correlations

**. Correlation is significant at the 0.01 level (2-tailed).

Source: statistical package for the social sciences output

According to Table No. (2), the correlation coefficients show positive significance for all variables with financial inclusion, except for the non-performing loan ratio. While there was a negative correlation coefficient between the non-performing loan ratio and the capital adequacy ratio and significant at the 1% level.

4.3. Inferential analysis4.3.1. Test the impact of digital financial services on financial inclusion

The study used multiple regression analysis in addition to cross-sectional data analysis to test this impact. Table No. (3) shows the results of the inferential analysis based on multiple regression analysis.

	Variables Entered/Removed ^a				Model Summary					
Model	Variables Entered	Variables Removed	Method		_		Adju	sted R	Std. Error of	
1	total cards, N.		Enter	Mode	I R	R Squa	re So	quare	the Estimate	
	Sale, N. ATMs ^b			1	.9	21 ^a .84	49	.848	.06499	
a. De b. All	ependent Variable: requested variable	f. incluion es entered.		A	ATMs	s. (constant), t	otal cards, i	4. T OINt3 C	i Gale, N.	
	Mod	lel	Su Sqi	m of uares	df	Mean Square	F	Sig.		
	1	Regress	ion	8.453	3	2.818	667.030	<.001 ^b	_	
		Residua	I	1.504	356	.004				
		Total		9.957	359					

Table No. (3): Multiple regression analysis of financial inclusion

a. Dependent Variable: f. incluion

b. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs

Source: statistical package for the social sciences outputs

According to table No. (3); The multiple regression analysis reveals that the coefficient (F) was 667.03, which is significant at the 1% level. This demonstrates how digital financial services have a significant impact on Egypt's financial inclusion rates. Based on the adjusted R-Square, the spread of digital financial services explains (84.8%) of the change in financial inclusion in Egypt. On the other hand, table No. (4) shows cross-sectional analysis.

Model 1: Fixed-effects, using 360 observations Included 30 cross-sectional units Time-series length = 12 Dependent variable: fincluion								
	Coefficient	Std.	Error	t-ratio	p-value			
const	-0.0305183	0.005	70154	-5.353	< 0.0001	***		
NATMs	0.0115316	0.00106223		10.86	< 0.0001	***		
NPointsofSale	0.00873562	0.001	00146	8.723	< 0.0001	***		
totalcards	0.0158941	0.00113734		13.97	< 0.0001	***		
Mean dependent var	0.34	49167 S.D. de		ependent var	0.	166537		
Sum squared resid	0.15	52025	S.E. 0	of regression		.021562		
LSDV R-squared	0.98	84731	Within	n R-squared	0.	.984731		
LSDV F(32, 327)	659	.0486	P-valu	e(F)	2	.2e-276		
Log-likelihood	887	.7484	Akaik	e criterion	-1	709.497		
Schwarz criterion	-158	31.255	Hanna	n-Quinn	-10	658.506		
rho	0.07	77166	Durbi	n-Watson	1.	.425873		

Table No. (4): Cross-sectional analysis of financial inclusion

Joint test on named regressors -Test statistic: F(3, 327) = 7029.85

with p-value = P(F(3, 327) > 7029.85) = 1.61392e-296

Test for differing group intercepts -Null hypothesis: The groups have a common intercept Test statistic: F(29, 327) = 100.263

with p-value = P(F(29, 327) > 100.263) = 2.6512e-144

Source: Gnu Regression, Econometrics and Time-series Library outputs

.a

According to table No. (4); The cross-sectional analysis reveals that the coefficient (F) was (659.0486), and this coefficient is significant at the 1% level. This demonstrates that digital financial services have a significant impact on Egypt's financial inclusion rates. Based on Within R-squared, the spread of digital financial services explains (98.47%) of the change in financial inclusion in Egypt.

4.3.2. Test the impact of digital financial services on the non-performing loan ratio under moderating role of financial inclusion:

The study used hierarchical regression analysis in addition to cross-sectional data analysis to test this impact. Table No. (5) shows the results of the inferential analysis based on hierarchical regression analysis.

	Variables Entered/Removed ^a				Model Summary				
Model	Variables Entered	Variables Removed	Method	-	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	total cards, N Enter Points of		1	.329 ^a	.108	.100	.07812		
	Sale, N. ATMs ^b				2	.918 ^b	.842	.840	.03290
				_	a Predictors' (Constant) total cards N Points of Sale N				
2	f. incluion ^b		Enter		AT	Ms			
a. D	ependent Variable:	npl%		-	b. Pre	edictors: (Co	nstant), total	cards. N. Points o	f Sale, N.

Table No. (5): hierarchical regression analysis of the non-performing loan ratio

b. All requested variables entered

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.329 ^a	.108	.100	.07812
2	.918 ^b	.842	.840	.03290

ių, i ATMs, f. incluion

	ANOVA									
Model		Sum of Squares	df	Mean Square	F	Sig.				
1	Regression	.263	3	.088	14.366	<.001 ^b				
	Residual	2.173	356	.006						
	Total	2.436	359							
2	Regression	2.051	4	.513	473.884	<.001°				
	Residual	.384	355	.001						
	Total	2.436	359							

ANOVA^a

a. Dependent Variable: npl%

b. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs

c. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs, f. incluion

Source: statistical package for the social sciences outputs

According to table No. (5); The hierarchical regression analysis without entering financial inclusion and then entering financial inclusion into the model shows that the coefficients (F) were (14.36) and (473.88) respectively. These coefficients are significant at the 1% level of significance. This demonstrates how significant it is that digital financial services have an impact on Egypt's financial inclusion rates. Based on adjusted R-Square, the spread of digital financial services explains (10%) of the change in the non-performing loan ratio without financial inclusion but explains (84%) of the change in the non-performing loan ratio within financial inclusion in Egypt. On the other hand, table (6) shows cross-sectional analysis.

	Model 2: Fixe	d-effects,	, using 360) observations		
	Include	ed 30 cros	ss-sectiona	al units		
	Ti	me-series	length = 1	12		
	De	ependent	variable: n	pl	1	
	Coefficient	Std.	Error	t-ratio	p-value	
const	0.0805483	0.002	98077	27.02	< 0.0001	***
NATMs	0.00257169	0.000	621085	4.141	< 0.0001	***
NPointsofSale	0.00236866	0.000	557387	4.250	< 0.0001	***
totalcards	0.00447487	0.0007	720564	6.210	< 0.0001	***
fincluion	-0.273028	0.027	77220	-9.849	< 0.0001	***
Mean dependent var	0.08	85816	S.D. d	ependent var	0	0.082367
Sum squared resid	0.03	38087	S.E. of	f regression	0	.010809
LSDV R-squared	0.98	84362	Withir	n R-squared	0	.253854
LSDV F(33, 326)	621	.8447	P-valu	e(F)	2	2.8e-273
Log-likelihood	113	6.898	Akaik	e criterion	-2	205.795
Schwarz criterion	-207	73.668	Hanna	n-Quinn	-2	153.259
rho	0.4	51222	Durbir	n-Watson	0	.743569

Table No. (6): Cross-sectional analysis of the non-performing loan ratio

Joint test on named regressors -Test statistic: F(4, 326) = 27.728

with p-value = P(F(4, 326) > 27.728) = 7.89623e-020

Test for differing group intercepts -

Null hypothesis: The groups have a common intercept Test statistic: F(29, 326) = 102.151with p-value = P(F(29, 326) > 102.151) = 3.40986e-145

Source: Gnu Regression, Econometrics and Time-series Library outputs

According to table No. (6); The cross-sectional analysis shows that the coefficient (F) was (621.8447) and this coefficient is significant at the 1% level of significance. This demonstrates how significant it is that digital financial services have an impact on the non-performing loan ratio under Egypt's financial inclusion rates. Based on Within R-squared, the spread of digital financial services and Egypt's financial inclusion explain (25.38%) of the change in the non-performing loan ratio in Egypt.

4.3.3. Test the impact of digital financial services on the capital adequacy ratio under moderating role of financial inclusion:

The study used hierarchical regression analysis in addition to cross-sectional data analysis to test this impact. Table No. (7) shows the results of the inferential analysis based on hierarchical regression analysis.

Table No. (7): hierarchical regression analysis of the capital adequacy ratio

 (),			J ~~~ ~ ~	
	Variables Ent	ered/Removed	a		
	Variables	Variables			
Model	Entered	Removed	Method		Madal
1	total cards, N.		Enter		1
	Points of Sale,				
	N. ATMs ^b				2
2	f. incluion ^b		Enter		a Pro

a. Dependent Variable: car

b. All requested variables entered.

Model Summary						
			Adjusted R	Std. Error of the		
Model	R	R Square	Square	Estimate		
1	.382ª	.146	.139	1.76612		
2	.398 ^b	.158	.149	1.75574		

a. Predictors: (Constant), total cards, N. Points of Sale, N. ATMsb. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs, f. incluion

Δ	N	o	ν	Α	а	
~		\sim				

ANOTA								
Model		Sum of Squares	df	Mean Square	F	Sig.		
1	Regression	189.944	3	63.315	20.298	.000 ^b		
	Residual	1110.430	356	3.119				
	Total	1300.374	359					
2	Regression	206.048	4	51.512	16.711	.000c		
	Residual	1094.326	355	3.083				
	Total	1300.374	359					

a. Dependent Variable: car

b. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs

c. Predictors: (Constant), total cards, N. Points of Sale, N. ATMs, f. incluion

Source: statistical package for the social sciences outputs

According to table No. (7); The hierarchical regression analysis without financial inclusion and then financial inclusion into the model shows that the coefficients (F) were (20.298) and (16.711), respectively. These coefficients are significant at the 1% level of significance. This demonstrates how significant it is that digital financial services and Egypt's financial inclusion have an impact on the capital adequacy ratio. Based on adjusted R-Square, the spread of digital financial services explains (13.9%) of the change on the capital adequacy ratio without financial inclusion in Egypt. On the other hand, table No. (8) shows a cross-sectional analysis.

Table No. (8): Cross-sectional analysis of the capital adequacy ratio

	Model 3: Fixe	d-effects,	, using 360	0 observations		
	Include	ed 30 cros	ss-sectiona	al units		
	Ti	me-series	length =	12		
	De	ependent	variable: c	ar		_
	Coefficient	Std. Error		t-ratio	p-value	
const	9.95375	0.0476232		209.0	< 0.0001	***
NATMs	-0.00211344	0.00992296		-0.2130	0.8315	
NPointsofSale	-0.00132597	0.00890527		-0.1489	0.8817	
totalcards	-0.0124700	0.0115123		-1.083	0.2795	
fincluion	4.91645	0.442909		11.10	< 0.0001	***
Mean dependent var	11.47894 S.D.		S.D. d). dependent var		.903211
Sum squared resid	9.722148		S.E. o	f regression	0.172692	
LSDV R-squared	0.992524		Within	n R-squared	0.953613	
LSDV F(33, 326)	1311.447		P-valu	ie(F)	0.000000	
Log-likelihood	139.2877		Akaik	e criterion	-210.5753	
Schwarz criterion	-78.	-78.44781		in-Quinn	-158.0389	
Rho	0.4	0.478026		n-Watson	0.696566	
Joint test on named regressors -						

Test statistic: F(4, 326) = 1675.46

with p-value = P(F(4, 326) > 1675.46) = 6.55698e-216

Test for differing group intercepts -Null hypothesis: The groups have a common intercept Test statistic: F(29, 326) = 1254.09

with p-value = P(F(29, 326) > 1254.09) = 0

Source: Gnu Regression, Econometrics and Time-series Library outputs

According to table No. (8); The cross-sectional analysis shows that the coefficient (F) was (1311.447), and this coefficient is significant at the 1% level of significance. This demonstrates how significant it is that Egypt's financial inclusion has an impact on the capital adequacy ratio without digital financial services. Egypt's financial inclusion explains (95.36%) of the change in the capital adequacy ratio in Egypt, according to Within R-squared.

4.4. Discussion of Results

The study provides strong evidence for a significant relationship between digital financial services (DFS) and financial inclusion in Egypt. The following analysis highlights the key findings and their implications for banking stability.

4.4.1. Strong Correlation Between DFS and Financial Inclusion

All the F statistics across different analyses (Tables No. 3 and 4) are highly significant (1% level), indicating a strong correlation between the spread of DFS and financial inclusion rates in Egypt. The R-squared values (Tables No. 3 and 4) further emphasize this point. The growth of DFS can explain up to 84.8% (adjusted R-squared) of the variation in financial inclusion.

4.4.2. Impact on Non-Performing Loan Ratio

Table 5 highlights a crucial aspect. While DFS alone explains a small portion (10%) of the variation in the non-performing loan ratio, including financial inclusion in the model significantly increases the explanatory power to 84%. This suggests that

DFS might indirectly improve bank health by fostering financial inclusion. Increased financial access could lead to better loan management and potentially lower NPLs.

However, a cross-sectional analysis that includes both DFS and financial inclusion reveals a weaker connection (25.38% explained variation). This warrants further investigation.

4.4.3. Impact on Capital Adequacy Ratio

The study found the capital adequacy ratio (CAR) yields mixed results compared to NPL. Table No. 7 shows that DFS has a moderately independent effect (13.9% explained variation) on CAR, potentially indicating improved bank stability. However, financial inclusion does significantly increase this effect. Interestingly, Table 8 reveals that financial inclusion (95.36% explained variation) plays a dominant role in influencing CAR, independent of DFS. This suggests a strong association between financial inclusion and a bank's ability to absorb potential losses. Collectively, these findings highlight significant implications for banking stability.

4.4.4. Overall Implications for Banking Stability

The study found evidence that DFS can be a powerful tool for driving financial inclusion in Egypt. Increased financial inclusion appears to be positively linked to improved banking stability through potentially lower NPLs and higher CARs. However, the precise mechanisms through which DFS contributes to banking stability require further exploration. The study also highlights the moderating role of financial inclusion in promoting banking stability.

4.4.5. Research Limitations

The study focuses on Egypt, which may limit the generalizability of the findings to other countries. Besides, further research could explore the long-term impact of DFS on banking stability in Egypt, and conduct comparative studies to assess the extent to which these findings apply to other international and emerging markets.

5. Conclusions and recommendations

5.1. Conclusions

The impact of digital financial services (DFS) on banking stability is a topic of ongoing theoretical discussion. Proponents of the "innovation-growth" perspective believe DFS strengthens banks, while the "innovation-fragility" viewpoint suggests they introduce risks. Financial inclusion may influence how DFS affects stability. However, the impact of DFS on banking stability is complex. On one hand, DFS can undermine the traditional banking sector by eroding deposits and revenues. The use of non-bank digital wallets for payments and transfers reduces demand for bank accounts and payment services. This can reduce bank deposits and fee income, negatively impacting profitability and solvency. On the other hand, DFS can support banking sector stability through financial inclusion. By bringing more people into the formal financial system, DFS expands the deposit base and lending opportunities for banks. Greater financial inclusion promotes economic growth and provides banks with more

diversified, stable funding sources. The data trails from digital financial services also allow improved credit risk assessment, supporting financial stability.

By investigating the banking sector in Egypt, the study revealed a significant increase in financial inclusion, rising from 14% at the end of 2011 to 64.8% by the end of 2022. On the other hand, there is a discrepancy between traditional and digital financial services in terms of growth rates in the Egyptian banking sector. The results indicate high growth rates of digital services, with the number of ATMs, bank cards, and POS experiencing the highest growth rates at 28.69%, 317.93%, 333.38%, and 472.54%, respectively. This was the result of the Central Bank's efforts to modernize the Egyptian banking sector since the start of the twenty-first century. The study's findings suggest that digital financial services play a crucial role in promoting financial inclusion. This aligns with previous research that has established a correlation between DFS and financial inclusion (e.g. Jack & Suri, 2014; Mbiti and Weil, 2017; Demirguc-Kunt et al., 2018; Ozili, 2018; Lenka and Barik, 2018; Kelikume, 2021; Risman et al., 2021); Sodokin et al., 2022; Chen et al., 2024; and de Sant'Anna and Figueiredo, 2024).

However, the impact is significantly enhanced under the influence of financial inclusion as a moderator. This result is consistent with previous studies that showed a correlation between financial inclusion and banking stability (e.g. Han and Melecky, 2013, Ozili, 2018; Barik and Pradhan, 2021; Vo and Nguyen, 2021). However, a U-shaped relationship between financial inclusion and financial stability is empirically concluded (Hua et al. 2023).

On one hand, the impact of financial inclusion on non-performing loan ratio is consistent with previous studies (e.g. Hakimi et al., 2024; Yang and Masron, 2024), while, these results were contradictory for both Ozili (2019) and Ozili (2021B). The study can explain this by showing the regulatory rules and the strictness of application between the countries under investigation in previous studies, in addition to the variation in the accuracy and adequacy of the data (length of the time series). On other hand, there is a scarcity of previous studies that addressed the relationship between financial inclusion and capital adequacy. Most studies dealt with the impact of capital adequacy on bank performance (Margono et al., 2020; Alnajjar and Othman, 2021) or bankruptcy (Abou-El-Sood, 2016; Hadjixenophontos, and Christodoulou-Volos, 2018; Nguyen, 2021).

The contribution of the moderating role of financial inclusion is clear whether using non-performing loan or capital adequacy. These findings align with prior literature (e.g. Beck et al., 2016; Anarfo and Abor, 2020, and de Sant'Anna and Figueiredo, 2024). Digital transformation has a substantial and dynamic impact on reducing credit risks in banks, while inclusive finance plays a mutually influential role. As the level of financial inclusion rises, the corresponding impact of decreasing risk will also grow. Consequently, banks must integrate financial inclusion more effectively in order to promote risk reduction and enhance the accuracy of risk assessment (Yang and Masron 2024).

Therefore, the Egyptian context supports "innovation-growth" implying that the DFS directly support financial inclusion and indirectly improve banking stability.

Further research can solidify our understanding of these relationships and guide policymakers in crafting effective strategies for a more inclusive and stable financial system.

5.2. Recommendations

This underscores the importance of adopting a holistic approach that integrates both digital financial services and financial inclusion initiatives into banking policies and regulations. Further research could delve deeper into the mechanisms through which digital financial services and financial inclusion interact to influence banking stability, providing valuable insights for policymakers and practitioners in Egypt and beyond. Moreover, CBE policies should aim at removing barriers and constraints such as excessive customer identification requirements that hinder people from gaining access to finance services.

According to the above, the following studies are suggested as future studies:

- A. Examine the long-term moderating role of financial inclusion in relation to digital financial services and banking stability: evidence from Egypt.
- B. Analyze the Moderating Role of Financial Inclusion between Digital Financial Services and Banking Stability: Evidence from Emerging Markets
- C. A comparative analysis of financial inclusion's moderating role in the impact of digital financial services on banking stability between international and emerging markets

Finally, there is a nuanced relationship between DFS, financial inclusion, and banking sector stability in Egypt. The overarching conclusion is that maximizing financial inclusion helps translate digital financial innovations into more resilient and inclusive banking systems. However, regulators must strike a delicate balance between competition and stability as underserved customers gain expanded access to both digital and traditional banking services.

ATMs	Automated Teller Machines	
CBE	Central Bank of Egypt	
DFSs	Digital Financial Services	
FDI	Foreign Direct Investment	
FPI	Foreign portfolio investment	
FSB	Financial Stability Board	
GDP	Gross domestic product	
IMF	International Monetary Fund	
NFIS	the National Financial Inclusion Strategy - Egypt	
POS	Point of Sale	
SPSS	Statistical Package for the Social Sciences	
GRETL	CTL Gnu Regression, Econometrics and Time-series Library.	

List of abbreviations

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