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DIGITAL FINANCIAL INCLUSION AND BANK STABILITY IN A DUAL BANKING SYSTEM: DOES FINANCIAL LITERACY MATTER?

Hasanul Banna[1,2]

[1] Manchester Metropolitan University, United Kingdom, b.banna@mmu.ac.uk
[2] Miyan Research Institute, International University of Business Agriculture and Technology, Dhaka, Bangladesh

ABSTRACT

This study examines the relationship between digital financial inclusion (DFI), financial literacy, and stability of conventional and Islamic banks across 15 countries from 2011 to 2020. The findings show that DFI significantly enhances the stability of conventional banks, particularly through increased customer engagement with digital financial services, improving asset quality and reducing risks. In contrast, the relationship between DFI and stability of Islamic banks is either insignificant or negative, which may be attributed to Shariah compliance requirements, product mismatches, and competition from conventional banks and FinTech firms. Furthermore, while DFI boosts stability in conventional banks, it also exposes them to potential risks such as digital bank runs, as seen in the case of Silicon Valley Bank (SVB) in 2023. Additionally, high financial literacy positively interacts with DFI to boost the stability of conventional banks but has a negative impact on Islamic banks. Arguably, financially literate customers may resist digital services that do not fully meet Islamic principles. The results highlight the need for tailored strategies in Islamic banking, including the development of Shariah-compliant digital products, enhanced financial literacy programs, and more robust risk management frameworks to mitigate vulnerabilities like digital bank runs and improve stability in the sector.

Keywords: Digital financial inclusion, Bank stability, Financial literacy, Dual-banking.
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I. INTRODUCTION

Digital financial services have been noted to significantly improve the stability, efficiency, and performance of banks while attracting new deposit and loan customers (Hua et al., 2023; Banna et al., 2021). A key driver of this is digital financial inclusion (DFI), which has played a pivotal role in restoring trust and confidence in the banking sector, particularly in the aftermath of the global financial crisis (Ahamed et al., 2021). Among digital finance tools, mobile banking stands out for its widespread impact on consumers and banks alike (Manyika et al., 2016; Banna & Alam, 2020). By 2020, digital financial services had brought 1.6 billion new customers into the banking system, reduced remittance costs by 3.3%, enabled $600 billion in cross-border transfers, provided $394 billion in SME financing, and facilitated nearly $1.3 billion in daily transactions via 850 million mobile money agent accounts (Pazarbasioglu et al., 2020; Sahay et al., 2020).

However, this rapid expansion has also presented challenges. Banks in developing countries often struggle with outdated technological infrastructures, lacking of FinTech awareness, and rising competition from private and shadow banks, which can strain transparency, accountability, and ethics, potentially undermining financial stability (Bao & Huang, 2021; Huang, 2018). The 2023 collapse of Silicon Valley Bank (SVB), driven by high levels of uninsured deposits and investments in hold-to-maturity securities, underscores the fragility that can accompany rapid digital expansion in the banking sector (Ali et al., 2023; Turner, 2023). Given these opposing forces, this study addresses a key question: Is digital financial inclusion beneficial or detrimental to bank stability, particularly within dual banking systems?

In this context, financial literacy emerges as a key element of technological education. It refers to the ability to understand and manage personal finances effectively, including recognizing financial risks (Klapper et al., 2013; Klapper & Lusardi, 2020; Angrisani et al., 2023). Essential financial concepts such as budgeting, saving, investing, and debt management fall under the umbrella of financial literacy (Al Rahahleh, 2022; Vovchenko et al., 2018), and its importance becomes even more pronounced as individuals engage with digital financial products and services (Morgan, 2021; Yoshino et al., 2020). In this sense, financial literacy can be compared to reading the fine print of a contract or decoding the complex mechanisms behind a financial application. Recognizing its significance, this study explores an additional question: Does financial literacy affect the relationship between digital financial inclusion and bank stability in dual banking systems?

Although a growing body of research has explored the macro-level connections between financial inclusion and bank sector stability (Ahamed & Mallick, 2019; Banna & Alam, 2020; Banna et al., 2022; Ozili, 2018; Vo et al., 2021; Danisman & Tarazi, 2020), most studies focus on broader macroeconomic factors such as growth, inflation, and monetary policy (Xi & Wang, 2023; Oanh et al., 2023). Research on financial literacy has also expanded, exploring dimensions like personal financial planning and the role of FinTech in societal welfare (Panos & Wilson, 2020; Bermeo-Giraldo et al., 2023). However, despite the growing recognition of the interconnectedness between digital financial inclusion, financial literacy, and bank stability, there remains limited research on how these factors interact within dual

banking systems, where both Islamic and conventional banks operate. This gap persists largely due to data limitations. To bridge this gap, this study examines the impact of financial literacy on the relationship between digital financial inclusion and bank stability within dual banking systems.

This research contributes to the existing literature in several important ways. First, it examines the potential relationship between digital financial inclusion and bank stability in dual banking systems, shedding light on the ongoing debate about how digital financial inclusion affects both conventional and Islamic banks. This is particularly relevant given the rapid global growth of Islamic finance, which expanded at a compound annual rate of 10.1% from 2016 to 2021, with Islamic banking assets projected to exceed USD 4 trillion by 2026 (Refinitiv, 2022). Islamic banks have demonstrated a superior ability to restore financial stability following the global financial crisis compared to their conventional counterparts (Banna et al., 2022).

Second, the study investigates how financial literacy shapes the connection between digital financial inclusion and bank stability. Third, it considers both demand- and supply-side proxies for digital financial inclusion indices. Finally, to ensure the robustness of the findings, the study employs various econometric techniques to analyze these relationships. By addressing these aspects, the study provides a comprehensive understanding of the interplay between digital financial inclusion, bank stability, and financial literacy, with a particular focus on dual banking systems.

The paper is structured as follows: Section II reviews relevant literature and presents the hypotheses for empirical testing. Section III describes the data sources, proxies, models, and estimation techniques. Section IV presents the main results and robustness tests, while Section V concludes the research.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The theoretical framework of this study is grounded in four key perspectives that reflect the dual nature of digital financial inclusion (DFI) on bank stability, exploring both its potential benefits and risks.

First, the finance-growth hypothesis underscores the positive correlation between financial development and economic growth (Beck et al., 2014a). Digital financial services catalyze economic expansion by making financial services accessible to more people, thereby increasing participation in the financial system (Kanga et al., 2022; Han & Melecky, 2013). In this context, DFI helps mitigate information asymmetry (Beck et al., 2014b) and enables banks to achieve economies of scale (Kacperczyk & Schnabl, 2013). By simplifying loan access, particularly for small and medium enterprises (SMEs), DFI addresses the 'missing middle' gap, which has traditionally hindered SME financing (Ozili, 2018; Banna & Alam, 2020).

However, DFI also brings with it significant risks. The second perspective cautions that the heavy reliance on digital financial models, especially by large, tech-oriented banks, may create moral hazard risks. As digital lending grows, banks may lend to both high- and low-quality borrowers, leading them to securitize these loans and offload risk, a practice that contributed to the 2008 Global Financial Crisis (Pierri & Timmer, 2020). In developing countries, where

regulatory frameworks are generally weak, large banks with advanced technology hold a competitive edge over smaller institutions, which could incentivize riskier practices among dominant banks (Bertay et al., 2013). The competition-stability hypothesis suggests that this technological concentration among large banks reduces market competition, potentially increasing bank risk-taking and moral hazard (Chan et al., 1986; Mishkin, 1999). Consequently, unchecked technological advances may compromise stability across the banking sector.

Third, the diffusion of technology theory argues that DFI's success depends on the quality of innovation and the robustness of the infrastructure. Even in technologically advanced economies, poor-quality financial innovations and inefficient infrastructure can lead to uneven growth and instability (Hua et al., 2023).

Finally, the collapse of Silicon Valley Bank (SVB) in 2023 exemplifies how DFI can destabilize banks. SVB experienced a rapid digital bank run, as customers, primarily tech-savvy clients in the startup sector, withdrew funds at unprecedented speeds due to concerns over the bank's health. This digitally enabled mass withdrawal drained SVB's cash reserves and led to its collapse in under 48 hours, highlighting the risks of accelerated withdrawals through digital channels (Ali et al., 2023). This incident underscores the urgent need for updated regulatory frameworks that can account for the high-speed nature of digital transactions and the vulnerabilities posed by digital-enabled rapid deposit outflows (Turner, 2023). As digital financial services continue to expand, this event suggests that financial inclusion must be balanced with stability measures to avoid similar disruptions in the future.

The literature on financial inclusion hints that DFI potentially enhances bank stability. Through remote financial transactions and services like e-commerce and mobile applications, DFI helps banks expand deposit collection, loan processing, and customer reach (Gomber et al., 2017; Vo et al., 2021). The cost-benefit hypothesis posits that DFI can improve bank performance, efficiency, and stability by reducing customer acquisition costs and reaching more customers. Danisman & Tarazi (2020) study 4,168 banks across 28 EU countries (2010–2017) and find that financial inclusion promotes stability, especially benefiting financially underserved populations, such as rural residents, youth, and the unemployed.

Further studies support the stability-enhancing effects of DFI. Ahamed & Mallick (2019) analyze data from 2,635 banks in 86 countries (2004–2012), revealing that financial inclusion positively influences bank stability. This finding is further reinforced in a later study by Ahamed et al. (2021). They show that financial inclusion improves bank efficiency, reduces deposit volatility, and enhances stability, especially in less regulated countries. In Asia, Vo et al. (2021) find that higher financial inclusion contributes to greater stability, lower costs, and increased market share for banks. Research in MENA and African banks also supports the positive relationship between inclusion and stability, demonstrating resilience even when factors like religion and demographic characteristics are considered (Neaime & Gaysset, 2018; Beck et al., 2014c; Ahamed & Mallick, 2019).

Taking lead from these studies, we may argue that DFI strengthens banks' resilience by expanding services to previously unbanked populations (Hannig & Jensen, 2010).

DFI reduces intermediation and inclusion costs, as digital channels are generally more cost-effective than traditional banking methods (Han & Melecky, 2013). By lowering deposit costs, DFI can contribute to a safer banking sector (Petersen & Rajan, 1995). On the other hand, the ease of access to low-cost funds may also encourage risk-taking, particularly among larger banks with abundant liquidity, potentially leading to instability in the long term (Bertay et al., 2013).

Considering the conflicting perspectives on digital financial inclusion (DFI) and its impact on banking stability—whether the benefits of DFI in expanding access, reducing costs, and enhancing efficiency outweigh the risks of moral hazard, increased competition, and the potential for rapid digital bank runs—this study proposes the following hypothesis:

H1: Digital financial inclusion is either beneficial or harmful for banking stability in dual-banking systems, depending on the balance of its associated risks and benefits.

Financial literacy has gained global recognition as a critical factor in economic well-being. Accurate data on financial literacy levels is essential, as emphasized by the Organization for Economic Co-operation and Development's International Network on Financial Education (OECD/INFE, 2015). Improving financial literacy is key to promoting financial inclusion, making financial products and services more accessible to individuals and businesses (Demirgüç-Kunt & Klapper, 2012). Those lacking financial knowledge face barriers to benefiting from increased access to financial services (Al Suwaidi & Mertzanis, 2024; Lusardi & Mitchell, 2014).

The rise of digital banking highlights the need for enhanced financial literacy to help individuals navigate new financial products and services effectively. The proliferation of information and communication technologies (ICT) has led to the emergence of digital banks like *Ant Financial* in China, *Grab* in Singapore, *Paytm* in India (Al Suwaidi & Mertzanis, 2024). Research shows that digital solutions, especially mobile banking, have significantly increased financial inclusion in developing economies with underdeveloped traditional financial systems (Demirgüç-Kunt & Singer, 2017). Previous studies have identified various factors influencing the adoption of digital financial services (Jack et al., 2013; Suri, 2017), underscoring the transformative potential of digitalization in closing financial access gaps. Thus, the second hypothesis is proposed:

H2: Financial literacy influences the relationship between digital financial inclusion and bank stability in dual-banking systems.

Despite considerable research on DFI's impacts on bank stability and the importance of financial literacy, key gaps remain. Most studies focus on developed economies and large banks, with limited examination of how DFI, financial literacy, and bank stability interact in dual-banking systems where Islamic and conventional banks coexist. Although demographic and regulatory factors have been studied, the specific influence of financial literacy on the DFI-stability nexus is underexplored. Additionally, developing countries face unique challenges such as technological disparities and moral hazard in large banks, demanding further

investigation. This study aims to address these gaps by examining how financial literacy influences the relationship between DFI and bank stability within dual-banking systems.

III. METHODOLOGY

3.1. Data

The final dataset consists of 3,350 bank-year observations from both listed and non-listed banks over the period of 2011-2020 across 15 countries: Bangladesh, Benin, Indonesia, Jordan, Kenya, Malaysia, Nigeria, Pakistan, Philippines, Qatar, Senegal, South Africa, Sudan, Thailand, and Tanzania. Indonesia represents the highest proportion of observations (23.94%), followed by Bangladesh (11.91%) and Malaysia (8.90%). The sample banks are selected based on the availability of DFI data and the presence of dual-banking systems in these countries, which feature both conventional and Islamic banking sectors.

Data on bank-specific variables are sourced from the Orbis Bank-Focus database. Information on digital financial inclusion is from the Financial Access Survey (FAS), International Monetary Fund (IMF), Global Findex (World Bank), and individual countries' central banks' reports. Macroeconomic variables are from World Bank sources, including the World Development Indicators (WDI) and Worldwide Governance Indicators (WGI). Table 1 provides detailed descriptions of the variables and their descriptive statistics.

3.2. Variables

Bank stability: Following Ahamed & Mallick (2019), two proxies for bank stability are used: 1) Z-score: A widely recognized measure of bank risk and distance-to-default. It is calculated as the return on average assets (ROAA) plus equity over total assets (EQT), divided by the standard deviation of ROAA (SDROAA), using a 3-year rolling window for each bank. 2) EQT/SDROAA: A measure of leverage or asset quality, representing equity over total assets divided by the standard deviation of ROAA. A higher Z-score indicates lower risk and greater bank stability, while a lower Z-score indicates higher risk and less stability. Banks with greater asset quality or leverage may experience higher stability. To mitigate potential skewness in the data, the natural logarithms of Z-score (LZS) and EQT/SDROAA (LEQT_SDROAA) are used, following the approaches of Ahamed and Mallick (2019).

Digital financial inclusion (DFI) indices: The study constructs a composite index of Digital Financial Inclusion (DFI), building on methodologies from previous studies by Ahamed & Mallick (2019) and Banna & Alam (2020). The DFI index is divided into two components—supply-side access (DFI_SA) and demand-side usage (DFI_DU)—to provide a comprehensive view of digital financial inclusion. This index considers both underserved and already served populations to reflect the reach and engagement of digital financial services across different segments, and its influence on bank stability.

The Supply-Side Access (DFI_SA) measures the accessibility of digital financial services, focusing on factors that facilitate access for all segments, particularly

underserved populations who traditionally face barriers in accessing financial services. The metrics include the number of mobile money agents, non-branch bank outlets, POS (point-of-sale) terminals per 100,000 adults, and mobile money agents per 1,000 km². These indicators reflect the physical presence and accessibility of digital financial services infrastructure, which is crucial for reaching underserved populations, especially in rural or remote areas where traditional bank branches may be scarce.

Enhanced accessibility expands financial inclusion, potentially stabilizing banks by broadening the customer base, increasing deposit inflows, and promoting engagement with both underserved and already served individuals (Banna et al., 2021). By lowering barriers to access, banks can reduce reliance on costly branch networks and gain operational efficiencies. However, expanding digital-only access points introduces the need to carefully manage risk, particularly if digital channels are dominated by larger banks, which could lead to market concentration and create potential stability risks if over-leveraged. Thus, while supply-side proxies generally promote bank stability, they require balanced deployment to prevent over-reliance on digital channels for access.

The Demand-Side Usage (DFI_DU) captures the actual usage of digital financial services, reflecting how individuals and businesses—both underserved and already served—engage with digital banking solutions. The metrics include the number of mobile money and e-money accounts per 1,000 adults, the number of mobile and internet banking transactions per 1,000 adults, and the total value of mobile and internet banking transactions. These indicators measure adoption and engagement levels with digital financial services.

Higher usage rates enhance bank stability by increasing transaction volumes, deposit levels, and customer engagement, thus expanding banks' revenue streams and fostering a more resilient financial system (Ahamed & Mallick, 2019). Digital usage also promotes financial inclusion by enabling customers to build credit histories and access a broader array of financial activities. For underserved groups, this access can be transformative, while for those already served, digital channels offer greater convenience and flexibility. However, a high volume of digital transactions can also introduce risks, particularly if it enables rapid fund movements during financial stress. This risk is exemplified by the potential for digital bank runs, where users can quickly withdraw large amounts, destabilizing banks during periods of economic uncertainty.

The DFI index—comprising supply and demand indicators—presents a nuanced measure of digital financial inclusion that considers both underserved and already served populations. Supply-side proxies capture access potential, while demand-side proxies reflect actual engagement. Together, these indicators provide a comprehensive view of how digital financial services impact banking stability across diverse user groups, highlighting both the advantages and risks associated with digital financial inclusion in dual-banking systems.

Previous studies often use proxies like the number of ATMs and bank branches; however, this study expands the scope by including more comprehensive digital financial service measures. Due to the potential for multicollinearity among the proxies, a two-stage Principal Component Analysis (PCA) is employed to capture the expected variation and address over-parameterization. The resulting supply-

side and demand-side indices are combined into an overall DFI index. These indices are normalized using a min-max scaling technique, ensuring values between 0 and 1.

Financial literacy: Following Al Suwaidi & Mertzanis (2024), data on financial literacy are obtained from the Standard & Poor's Global Financial Literacy Survey (2014) of more than 150,000 adults across 140 economies. Since financial literacy data are available for only one year, a high and low financial literacy categorization was constructed. 1) High Financial Literacy (FIN_LIT_H): A dummy variable that takes a value of one if a country's financial literacy exceeds the cross-country average and zero otherwise. 2) Low Financial Literacy (FIN_LIT_L): measured as one minus high financial literacy. A Chi-square test is conducted to determine the difference between high and low financial literacy groups.

Bank-specific and macro-economic variables: This study incorporates several bank-specific and macroeconomic control variables. In line with Fang et al. (2014), the ratio of total loans to total assets (Loan Ratio - LR) is employed to measure liquidity risk for individual banks. To address potential size effects and loan portfolio risk, the logarithm of total assets (Bank Size - SIZE) and the loan loss provision to total loans (Loan Loss Provision Ratio - LLPR) are used, respectively. Additionally, the ratio of non-interest income to total operating income (Revenue Diversification - IND) accounts for the uncertain impact of off-balance sheet activities. Recognizing the role of management in mitigating excessive risk-taking, the ratio of total earning assets to total assets (Management Quality - MQ) is included as a proxy for management quality. Capital risk is captured by the equity-to-total-assets ratio (Capitalization - CAP). Lastly, the Herfindahl-Hirschman Index (HHI) and the Lerner Index (LINDEX) are applied to control for market concentration and market power, respectively.

Among the country-specific macroeconomic variables, this study considers the annual GDP growth rate (GDPG), inflation (INFL), unemployment rate (UNEMPY), and the Good Governance/Institutional Quality (GG) index, as published by the World Bank and Kaufmann et al. (2010). A standardized approach is used to measure institutional quality through the GG index, as these variables are highly correlated.

3.3. Models and Estimation

The following two regression models specify the relationship between DFI and bank stability and how financial literacy moderates this relationship:

$$Y_{ijt} = \alpha + \beta DFI_{jt} + \gamma B_{ijt} + \varphi M_{jt} + \varepsilon_{ijt} \quad (1)$$

$$Y_{ijt} = \alpha + \beta_1 (DFIxFIN\_LIT\_H)_{jt} + \beta_2 (DFIxFIN\_LIT\_L)_{jt} + \gamma B_{ijt} + \varphi M_{jt} + \varepsilon_{ijt} \quad (2)$$

Y_{ijt} is a measure of bank stability (i.e., LZS and LEQT_SDROAA) for bank 'i' of country 'j' in year 't'; DFI_{jt} is Digital Financial Inclusion index of country 'j' in year 't'; $DFIxFIN\_LIT\_H_{jt}$ is the interaction between Digital Financial Inclusion

index and High financial literacy of country '*j*' in year '*t*'; $(DFIxFIN\_LIT\_L)_{jt}$ is the interaction between Digital Financial Inclusion index and Low financial literacy of country '*j*' in year '*t*'; B_{ijt} is a vector of bank-specific factors of bank '*i*' of country '*j*' in year '*t*'; M_{jt} is a vector of macroeconomic factors of country '*j*' in year '*t*'; β_1, β_2, γ, φ are coefficients of the variables; and ε_{ijt} = Error term.

To ensure robustness, the study employs the Cameron, Gelbach, & Miller (2011) two-way clustering (CGM) estimation technique, with heteroscedasticity-corrected clustered robust standard errors to account for serial correlation and cross-sectional dependence. To address endogeneity concerns and sample selection bias, the study uses two-stage least squares (2SLS-IV) and Propensity Score Matching (PSM) methods.

IV. RESULTS AND ANALYSIS

4.1. Descriptive Statistics

Table 1 shows that the sample banks have a Z-score of 3.8, with a standard deviation (SD) of 1.11. The mean and SD for bank size (7.45 and 1.75, respectively) indicate considerable variation in size among the banks. On average, the Digital Financial Inclusion (DFI) index has a score of 0.36, suggesting that a significant portion of the population in the sample countries remains excluded from digital financial services. This supports the argument that approximately 1.4 billion people globally are still unbanked (World Bank, 2022). Financial literacy in the sample has an average score of 0.305. The sample countries show an average GDP growth rate of 4.88% and an unemployment rate of 4.91%. To avoid potential multicollinearity issues, a Pearson's pairwise correlation test is performed (Appendix A1).

Table 1.
Descriptive Statistics

Variables	Definition	Obs	Mean	SD	Min	Max
Dependent variables: Bank stability						
LZS	Log of Return on average assets (ROAA) plus Equity over total assets (EQT)divided by standard deviation of ROAA (SDROAA) using 3-years rolling window of each bank	3350	3.825	1.108	1.283	5.558
LEQT_SDROAA	Log of (EQT/SDROAA)	3350	3.766	1.223	-2.723	9.123
Main independent variables						
DFI	Digital financial inclusion composite index	3350	0.36	0.267	0	0.878
DFI_SA	Digital financial inclusion supply side or access index	3350	0.363	0.256	0	1
DFI_DU	Digital financial inclusion demand side or usage index	3350	0.357	0.333	0	0.999
FIN_LIT	S&P global financial literacy survey 2014	3350	0.305	0.069	0.192	0.417

Table 1.
Descriptive Statistics (Continued)

Variables	Definition	Obs	Mean	SD	Min	Max
	Bank-specific variables					
SIZE	Bank size – Log of total assets	3350	7.485	1.746	2.133	10.2
IND	Revenue diversification - non-interest income/total operating income	3350	35.009	20.742	3.337	82.637
LR	Loan ratio – total loans/total assets	3350	0.588	0.152	0.169	0.806
LLPR	Loan loss provision ratio - Loan loss provision/total assets	3350	0.006	0.008	-0.002	0.033
MQ	Management quality - Total earning assets/total assets	3350	0.834	0.096	0.505	0.958
CAP	Capitalization – total equity/total assets	3350	0.142	0.083	0.05	0.479
HHI	Herfindahl-Hirschman Index based on total loans	3350	0.114	0.068	0.071	0.507
LINDEX	Lerner Index	3350	0.291	0.105	0.094	0.435
	Macroeconomic variables					
GDPG	Annual growth rate of GDP	3350	4.884	1.877	-0.055	9.174
INF	Inflation	3350	4.763	3.379	0.583	15.438
UM	Unemployment rate	3350	4.909	4.148	0.72	17
IQ	Institutional quality – Standardization using the Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/ Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability.	3350	0.252	0.646	-1.299	1.314

4.2. Results

4.2.1. Digital Financial Inclusion and Bank Stability

The baseline analysis is divided into two dimensions: (a) two proxies for bank stability (LZS and LEQT_SDROAA), and (b) three proxies for DFI (DFI, DFI_SA, and DFI_DU) for each of the two stability proxies.

Table 2.
Digital Financial Inclusion and Bank Stability

	Dependent variables					
	LZS			LEQT_SDROAA		
	(1)	(2)	(3)	(4)	(5)	(6)
DFI	0.626***			0.741***		
	(0.167)			(0.181)		
DFI_SA		0.292			0.325	
		(0.184)			(0.198)	
DFI_DU			0.531***			0.635***
			(0.130)			(0.142)
LISTED	0.099	0.091	0.102	0.120	0.111	0.124*
	(0.069)	(0.069)	(0.068)	(0.075)	(0.075)	(0.075)
SIZE	0.190***	0.189***	0.188***	0.183***	0.182***	0.181***
	(0.021)	(0.021)	(0.021)	(0.024)	(0.024)	(0.023)
IND	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
LR	0.706***	0.714***	0.718***	0.749***	0.758***	0.763***
	(0.235)	(0.238)	(0.234)	(0.266)	(0.270)	(0.265)
LLPR	-43.085***	-43.434***	-42.777***	-41.233***	-41.630***	-40.865***
	(3.287)	(3.270)	(3.289)	(3.490)	(3.482)	(3.492)
MQ	1.093***	0.992***	1.139***	1.121***	1.003***	1.176***
	(0.339)	(0.346)	(0.337)	(0.377)	(0.386)	(0.375)
CAP	3.058***	3.108***	3.038***	3.615***	3.675***	3.590***
	(0.441)	(0.441)	(0.442)	(0.506)	(0.507)	(0.506)
HHI	0.249	-0.455	0.340	0.422	-0.429	0.541
	(0.755)	(0.718)	(0.750)	(0.818)	(0.778)	(0.812)
LINDEX	-0.695	-0.465	-0.835	-0.965*	-0.697	-1.133**
	(0.506)	(0.522)	(0.510)	(0.538)	(0.559)	(0.542)
GDPG	-0.079***	-0.086***	-0.075***	-0.086***	-0.093***	-0.081***
	(0.021)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
INF	0.000	0.008	-0.004	0.002	0.011	-0.004
	(0.012)	(0.012)	(0.012)	(0.013)	(0.014)	(0.013)
UM	0.030***	0.018**	0.034***	0.030***	0.016*	0.035***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
IQ	0.085	0.217**	0.063	0.106	0.264**	0.077
	(0.099)	(0.090)	(0.099)	(0.110)	(0.103)	(0.110)
Constant	1.155***	1.209***	1.143***	1.087**	1.150***	1.072**
	(0.387)	(0.390)	(0.386)	(0.428)	(0.430)	(0.427)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	26.196***	24.646***	26.464***	22.775***	21.485***	23.028***
Adjusted R-square	0.298	0.293	0.300	0.270	0.264	0.272
Observations	3350	3350	3350	3350	3350	3350

Clustered Standard errors are in parenthesis

*** *p<0.01, ** p<0.05, * p<0.1*

Table 2 shows that DFI has a significant positive relationship with both the Z-score and asset quality (measured as leverage). Two main takeaways emerge from these results: a) A higher level of DFI increases both the Z-score and asset quality, thus enhancing bank stability. b) The coefficients suggest that a one standard deviation increase in the overall DFI index (SD = 0.267) increases the Z-score by approximately 16.71% (0.267 x 0.626) and asset quality by about 19.79% (0.267 x 0.741). These results are substantial enough to be of interest to policymakers.

The findings are consistent with recent studies (Banna & Alam, 2021; Ahamed et al., 2021; Danisman & Tarazi, 2020; Ahamed & Mallick, 2019). The results also show that DFI_DU (demand-side digital financial inclusion) has a positive impact on both the Z-score and asset quality, while DFI_SA (supply-side digital financial inclusion) shows an insignificant relationship. This suggests that DFI_DU, which reflects the active usage of digital financial services—representing direct customer engagement—plays a more substantial role in enhancing bank stability, as it brings in transaction fees, strengthens customer relationships, and generates reliable revenue streams. In contrast, the insignificant result of DFI_SA suggests that over-expansion of digital service points without corresponding growth in actual usage can introduce operational costs without directly strengthening banks' financial positions. Increased points of access can lead to heightened operating expenses, maintenance costs, and security vulnerabilities, which may even dilute banks' risk-adjusted performance metrics if not matched by profitable usage levels (Unnikrishnan et al., 2019). This effect may render DFI_SA insignificant when it does not correspond to an increase in productive transactions or deposits that drive stability indicators.

The findings indicate that an inclusive financial system contributes to bank stability through three primary channels: a) DFI promotes economies of scale, inclusiveness, openness, and stable deposits at low costs, with low monitoring costs and risks (Ahamed & Mallick, 2019; Danisman & Tarazi, 2020; Manyika et al., 2016). b) DFI helps mitigate financial constraints for SMEs and individuals, thereby increasing financial mobilization (Ahamed & Mallick, 2019). This enables banks to minimize liquidity shortfalls and reduce pro-cyclicality risks (Han & Melecky, 2013). c) DFI allows banks to set lending priorities more effectively, perform client analyses, and plan strategies to reduce non-performing loans (NPLs) and default risk (Morgan & Pontines, 2018). These results show that DFI is beneficial for the stability of banks in the overall sample, thereby supporting the first hypothesis of this study.

4.2.2. Digital Financial Inclusion and Bank Stability (Conventional vs Islamic Banks)

In Tables 3 and 4, the sample is divided into conventional and Islamic banks to explore the differing impacts of DFI on bank stability.

Table 3.
Digital Financial Inclusion and Bank Stability (Conventional Banks)

	Dependent variables					
	LZS			LEQT_SDROAA		
	(1)	(2)	(3)	(4)	(5)	(6)
DFI	0.686***			0.830***		
	(0.186)			(0.202)		
DFI_SA		0.290			0.331	
		(0.203)			(0.218)	
DFI_DU			0.604***			0.738***
			(0.144)			(0.157)
LISTED	0.171**	0.170**	0.171**	0.211***	0.210***	0.212***
	(0.073)	(0.073)	(0.073)	(0.080)	(0.080)	(0.080)
SIZE	0.192***	0.190***	0.190***	0.189***	0.186***	0.186***
	(0.023)	(0.023)	(0.023)	(0.025)	(0.026)	(0.025)
IND	-0.009***	-0.010***	-0.009***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
LR	0.684***	0.670**	0.710***	0.693**	0.677**	0.725**
	(0.259)	(0.264)	(0.258)	(0.293)	(0.299)	(0.291)
LLPR	-44.343***	-44.233***	-44.232***	-42.350***	-42.206***	-42.218***
	(3.452)	(3.443)	(3.452)	(3.723)	(3.731)	(3.718)
MQ	0.957**	0.864**	1.015**	1.057**	0.946**	1.130**
	(0.408)	(0.419)	(0.404)	(0.459)	(0.471)	(0.455)
CAP	3.625***	3.682***	3.601***	4.255***	4.324***	4.225***
	(0.462)	(0.460)	(0.462)	(0.530)	(0.530)	(0.530)
HHI	0.599	-0.246	0.767	0.752	-0.288	0.968
	(0.869)	(0.837)	(0.856)	(0.938)	(0.915)	(0.920)
LINDEX	-0.568	-0.360	-0.718	-0.943	-0.695	-1.127*
	(0.616)	(0.643)	(0.614)	(0.664)	(0.698)	(0.663)
GDPG	-0.095**	-0.104**	-0.090*	-0.115**	-0.125**	-0.109**
	(0.045)	(0.047)	(0.046)	(0.049)	(0.051)	(0.050)
INF	-0.005	0.002	-0.011	-0.003	0.006	-0.009
	(0.013)	(0.014)	(0.013)	(0.014)	(0.015)	(0.014)
UM	0.034***	0.016	0.040***	0.036***	0.016	0.045***
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)
IQ	0.056	0.239**	0.012	0.071	0.296**	0.015
	(0.123)	(0.114)	(0.123)	(0.135)	(0.130)	(0.134)
Constant	1.166***	1.259***	1.127**	1.061**	1.174**	1.013**
	(0.444)	(0.450)	(0.442)	(0.498)	(0.502)	(0.496)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	25.585***	23.325***	26.233***	21.434***	19.935***	21.794***
Adjusted R-square	0.303	0.297	0.305	0.280	0.272	0.283
Observations	2903	2903	2903	2903	2903	2903

Clustered Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Table 3 shows that for conventional banks, DFI has a significant positive relationship with bank stability. In contrast, Table 4 shows that for Islamic banks, the relationship between DFI and bank stability is either insignificant or negative.

The negative or insignificant impact of DFI on Islamic bank stability can be attributed to several factors such as the unique risk structure of Islamic banks, a mismatch between digital financial products and Islamic finance principles, increased competition from conventional banks and FinTech firms, operational and technological challenges specific to Islamic banks, customer behavior that is more cautious when it comes to adopting digital financial services (Banna & Alam, 2021). These factors suggest that while digital financial inclusion can benefit conventional banks, its impact on Islamic banks is more complex and may require tailored strategies to align with Shariah-compliant principles and customer preferences.

Drawing parallels to the Silicon Valley Bank (SVB) collapse in 2023, the rise of digital transactions can amplify vulnerabilities, especially when financial institutions, like Islamic banks, are not well-equipped to handle rapid, large-scale digital transactions (Ali et al., 2023; Turner, 2023). SVB's failure was precipitated by a digital bank run, where customers withdrew funds rapidly through digital channels (Ali et al., 2023). This highlights how digital financial inclusion, if not properly managed, can lead to instability, particularly for banks that are not fully aligned with technological advances or customer behavior. For Islamic banks, the lack of sufficient digital infrastructure and the challenges in balancing Shariah compliance with digital innovations could exacerbate the risks, leading to a negative or insignificant relationship between DFI and their stability.

Table 4.
Digital Financial Inclusion and Bank Stability (Islamic Banks)

	Dependent variables					
	LZS			**LEQT_SDROAA**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
DFI	-0.997**			-0.916*		
	(0.471)			(0.478)		
DFI_SA		-0.187			0.059	
		(0.553)			(0.664)	
DFI_DU			-0.895**			-0.904**
			(0.366)			(0.387)
LISTED	-0.173	-0.165	-0.182	-0.221	-0.215	-0.230
	(0.177)	(0.175)	(0.179)	(0.198)	(0.197)	(0.201)
SIZE	0.206***	0.185***	0.215***	0.193**	0.174**	0.203**
	(0.067)	(0.067)	(0.067)	(0.084)	(0.085)	(0.083)
IND	-0.005*	-0.005	-0.005	-0.006*	-0.005	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LR	0.697	0.697	0.657	0.829	0.823	0.787
	(0.554)	(0.554)	(0.564)	(0.636)	(0.633)	(0.644)
LLPR	-33.123***	-32.716***	-34.039***	-33.456***	-33.461***	-34.381***
	(8.809)	(8.999)	(8.615)	(9.444)	(9.689)	(9.333)

Table 4.
Digital Financial Inclusion and Bank Stability (Islamic Banks) (Continued)

	Dependent variables					
	LZS			LEQT_SDROAA		
	(1)	(2)	(3)	(4)	(5)	(6)
MQ	1.421*	1.373*	1.518**	1.015	0.976	1.121
	(0.745)	(0.724)	(0.753)	(0.824)	(0.801)	(0.831)
CAP	1.355	1.258	1.402	1.789	1.702	1.846
	(1.149)	(1.161)	(1.151)	(1.359)	(1.373)	(1.360)
HHI	-2.691*	-1.219	-2.933*	-2.088	-0.493	-2.487
	(1.557)	(1.589)	(1.552)	(1.701)	(1.845)	(1.641)
LINDEX	-1.955	-1.594	-1.652	-1.722	-1.143	-1.471
	(1.294)	(1.439)	(1.240)	(1.291)	(1.578)	(1.238)
GDPG	-0.117***	-0.122***	-0.123***	-0.131***	-0.142***	-0.136***
	(0.032)	(0.033)	(0.032)	(0.028)	(0.030)	(0.028)
INF	0.049	0.049	0.051	0.024	0.023	0.027
	(0.031)	(0.033)	(0.031)	(0.031)	(0.032)	(0.031)
UM	0.024	0.032*	0.022	0.012	0.020	0.009
	(0.017)	(0.017)	(0.017)	(0.019)	(0.020)	(0.019)
IQ	0.390	0.265	0.410	0.279	0.136	0.314
	(0.255)	(0.265)	(0.246)	(0.284)	(0.295)	(0.268)
Constant	1.328	1.137	1.191	1.847**	1.599*	1.727**
	(0.820)	(0.810)	(0.814)	(0.834)	(0.861)	(0.843)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	13.574***	12.383***	14.130***	10.835***	10.073***	10.825***
Adjusted R-square	0.350	0.342	0.353	0.297	0.292	0.301
Observations	447	447	447	447	447	447

Clustered Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

4.2.3. The Role of Financial Literacy on the Nexus Between Digital Financial Inclusion and Bank Stability

This section explores whether high financial literacy influences the relationship between DFI and bank stability. Table 5 shows that the interaction between DFI and high financial literacy has a significant positive relationship with bank stability for the full sample and for conventional banks. However, their interactions carry negative coefficients.

The documented positive coefficient of the interaction terms for conventional banks can be explained by the compatibility between financial literacy and the broad range of digital financial products in conventional banking, which enhances customer engagement, efficiency, and profitability (Klapper et al., 2013). In contrast, the negative coefficients for Islamic banks may stem from the unique requirements of Shariah-compliant financial products, where financially literate

customers are more cautious or resistant to digital financial services that do not fully meet Islamic principles (Lukonga, 2015). This leads to lower digital adoption and potentially weaker financial performance, reducing stability in Islamic banks.

The SVB incident underscores how digital financial inclusion, while beneficial in many contexts, can introduce risks for banks—especially those not fully prepared for the increased pace and scale of digital transactions (Ali et al., 2023). For Islamic banks, this dynamic may be even more pronounced. The caution among Islamic banking customers in adopting digital services, combined with the operational and technological challenges of integrating Shariah-compliant products with digital solutions, could exacerbate instability. Without effective digital adoption and tailored offerings that meet both customer expectations and religious principles, Islamic banks may struggle to achieve the same stability benefits from digital inclusion that conventional banks experience.

Overall, the results suggest that the rise of digital banking requires enhanced financial literacy to help individuals navigate new financial products and services effectively, ultimately improving bank stability. These findings support the second hypothesis.

Table 5.
Financial Literacy, Digital Financial Inclusion and Bank Stability

	Full sample		**Conventional banks**		**Islamic banks**	
	Dependent variables					
	LZS	**LEQT_ SDROAA**	**LZS**	**LEQT_ SDROAA**	**LZS**	**LEQT_ SDROAA**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
DFI × FIN_LIT_H	0.625***	0.743***	0.682***	0.831***	-0.980**	-0.902*
	(0.167)	(0.182)	(0.187)	(0.203)	(0.465)	(0.472)
DFI × FIN_LIT_L	0.699	0.598	0.909*	0.797	-1.493*	-1.300
	(0.448)	(0.508)	(0.507)	(0.580)	(0.880)	(0.933)
LISTED	0.099	0.120	0.170**	0.211***	-0.172	-0.219
	(0.069)	(0.075)	(0.073)	(0.080)	(0.177)	(0.198)
SIZE	0.190***	0.183***	0.192***	0.189***	0.206***	0.193**
	(0.021)	(0.024)	(0.023)	(0.025)	(0.067)	(0.084)
IND	-0.008***	-0.008***	-0.009***	-0.010***	-0.005*	-0.005*
	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
LR	0.706***	0.750***	0.683***	0.693**	0.708	0.838
	(0.235)	(0.266)	(0.260)	(0.294)	(0.557)	(0.638)
LLPR	-43.097***	-41.210***	-44.368***	-42.346***	-32.895***	-33.279***
	(3.294)	(3.496)	(3.459)	(3.728)	(8.930)	(9.573)
MQ	1.093***	1.121***	0.956**	1.058**	1.402*	1.000
	(0.339)	(0.377)	(0.408)	(0.459)	(0.746)	(0.825)
CAP	3.057***	3.616***	3.622***	4.256***	1.354	1.789
	(0.442)	(0.507)	(0.462)	(0.531)	(1.144)	(1.356)
HHI	0.247	0.425	0.594	0.753	-2.669*	-2.069
	(0.756)	(0.819)	(0.870)	(0.938)	(1.550)	(1.695)

Table 5.
Financial Literacy, Digital Financial Inclusion and Bank Stability (Continued)

	Full sample		Conventional banks		Islamic banks	
	Dependent variables					
	LZS	LEQT_ SDROAA	LZS	LEQT_ SDROAA	LZS	LEQT_ SDROAA
	(1)	(2)	(3)	(4)	(5)	(6)
LINDEX	-0.692	-0.972*	-0.553	-0.946	-1.959	-1.725
	(0.510)	(0.543)	(0.620)	(0.671)	(1.295)	(1.293)
GDPG	-0.079***	-0.087***	-0.093**	-0.116**	-0.118***	-0.132***
	(0.021)	(0.022)	(0.045)	(0.049)	(0.033)	(0.028)
INF	0.001	0.002	-0.005	-0.003	0.048	0.024
	(0.012)	(0.013)	(0.013)	(0.014)	(0.031)	(0.031)
UM	0.030***	0.030***	0.034***	0.036***	0.024	0.012
	(0.009)	(0.009)	(0.012)	(0.013)	(0.017)	(0.019)
IQ	0.086	0.104	0.058	0.071	0.392	0.281
	(0.099)	(0.110)	(0.123)	(0.136)	(0.256)	(0.285)
Constant	1.154***	1.090**	1.157***	1.063**	1.326	1.846**
	(0.388)	(0.430)	(0.447)	(0.501)	(0.817)	(0.833)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	25.256***	21.950***	24.669***	20.663***	13.215***	10.783***
Adjusted R-square	0.298	0.270	0.303	0.280	0.348	0.296
Observations	3350	3350	2903	2903	447	447

Clustered Standard errors are in parenthesis

*** *p<0.01, ** p<0.05, * p<0.1*

4.3. Robustness Tests

A series of robustness tests are conducted in this study. First, an alternative proxy for bank stability is used. Second, an alternative measure for digital financial inclusion is employed. Third, a two-stage least squares instrumental variable (2SLS-IV) regression is used to address potential endogeneity, and finally, propensity score matching (PSM) is applied to minimize sample selection bias and endogeneity issues.

4.4. Alternative Bank Stability Variable

Following Ahamed & Mallick (2019) and Banna & Alam (2021), this study considers the volatility of ROAA as an alternative proxy for bank stability in Table 6. To maintain consistency with the Z-score, the logarithm of the SDROAA is multiplied by -1. The results remain similar to the baseline findings.

Table 6.
Alternative Bank Stability

	Full sample		Conventional banks		Islamic banks	
	Dependent variable: Volatility of ROAA (- LN(SDROAA))					
	(1)	(2)	(3)	(4)	(5)	(6)
DFI	0.631***		0.736***		-0.704	
	(0.218)		(0.244)		(0.661)	
DFI × FIN_LIT_H		0.632***		0.734***		-0.679
		(0.217)		(0.244)		(0.655)
DFI × FIN_LIT_L		0.543		0.876		-1.377
		(0.510)		(0.575)		(1.168)
LISTED	0.114	0.115	0.129	0.128	-0.041	-0.039
	(0.099)	(0.099)	(0.109)	(0.109)	(0.248)	(0.249)
SIZE	0.260***	0.260***	0.257***	0.257***	0.368***	0.367***
	(0.031)	(0.031)	(0.033)	(0.033)	(0.080)	(0.081)
IND	-0.009***	-0.009***	-0.008***	-0.008***	-0.010*	-0.009*
	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)
LR	0.677**	0.677**	0.857***	0.856***	-1.091	-1.075
	(0.300)	(0.300)	(0.326)	(0.327)	(0.972)	(0.976)
LLPR	-48.644***	-48.622***	-51.412***	-51.437***	-21.839	-21.362
	(6.681)	(6.697)	(7.131)	(7.147)	(16.991)	(17.008)
MQ	1.538***	1.538***	1.359**	1.358**	3.896**	3.868**
	(0.452)	(0.452)	(0.533)	(0.534)	(1.685)	(1.687)
CAP	0.505	0.506	0.640	0.638	0.798	0.795
	(0.580)	(0.580)	(0.662)	(0.662)	(1.129)	(1.129)
HHI	1.023	1.025	1.461	1.457	-3.358	-3.321
	(0.920)	(0.920)	(1.065)	(1.066)	(2.097)	(2.079)
LINDEX	-0.356	-0.361	0.172	0.183	-0.107	-0.110
	(0.688)	(0.692)	(0.805)	(0.810)	(1.531)	(1.530)
GDPG	-0.008	-0.008	0.095	0.096	-0.130***	-0.132***
	(0.034)	(0.034)	(0.068)	(0.068)	(0.043)	(0.043)
INF	0.025	0.025	0.016	0.016	0.056	0.056
	(0.017)	(0.017)	(0.018)	(0.018)	(0.053)	(0.053)
UM	0.037***	0.037***	0.051***	0.051***	0.055**	0.055**
	(0.012)	(0.012)	(0.016)	(0.016)	(0.028)	(0.028)
IQ	-0.006	-0.007	-0.098	-0.096	0.331	0.333
	(0.125)	(0.125)	(0.157)	(0.157)	(0.367)	(0.369)
Constant	-2.203***	-2.201***	-2.476***	-2.481***	-3.995**	-3.996**
	(0.554)	(0.556)	(0.635)	(0.638)	(1.624)	(1.621)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	12.631***	12.218***	11.332***	10.922***	7.089***	6.785***
Adjusted R-square	0.183	0.183	0.177	0.177	0.270	0.269
Observations	3035	3035	2628	2628	407	407

Clustered Standard errors are in parenthesis

*** *p<0.01, ** p<0.05, * p<0.1*

4.5. Alternative Digital Financial Inclusion Variable

In Table 7, following Banna & Alam (2021), this study uses 'the percentage of adults who made or received digital payments in the past year' (DFI_A) as an alternative proxy for DFI, with data sourced from the Global Findex database. This proxy measures the ratio of total digital financial transactions to each country's GDP. The results again are consistent with the baseline findings.

Table 7.
Alternative Digital Financial Inclusion

	Full sample		Conventional banks		Islamic banks	
	Dependent variable: LZS					
	(1)	(2)	(3)	(4)	(5)	(6)
DFI_A	0.004**		0.005**		-0.014**	
	(0.002)		(0.002)		(0.007)	
DFI_A × FIN_LIT_H		0.005**		0.005**		-0.014**
		(0.002)		(0.002)		(0.007)
DFI_A × FIN_LIT_L		-0.002		-0.001		-0.017
		(0.005)		(0.005)		(0.034)
LISTED	0.126*	0.124*	0.176**	0.174**	-0.115	-0.115
	(0.070)	(0.070)	(0.073)	(0.073)	(0.209)	(0.210)
SIZE	0.184***	0.185***	0.185***	0.186***	0.234***	0.235***
	(0.022)	(0.022)	(0.024)	(0.024)	(0.065)	(0.067)
IND	-0.007***	-0.007***	-0.010***	-0.010***	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
LR	0.833***	0.838***	0.810***	0.815***	0.432	0.434
	(0.238)	(0.238)	(0.261)	(0.261)	(0.802)	(0.806)
LLPR	-42.655***	-42.652***	-43.108***	-43.105***	-33.638***	-33.615***
	(3.273)	(3.269)	(3.506)	(3.501)	(9.477)	(9.482)
MQ	1.110***	1.105***	1.013**	1.007**	2.315***	2.309**
	(0.347)	(0.347)	(0.394)	(0.395)	(0.871)	(0.875)
CAP	3.382***	3.399***	3.643***	3.660***	2.181**	2.190**
	(0.426)	(0.426)	(0.458)	(0.459)	(1.038)	(1.055)
HHI	0.455	0.496	0.165	0.205	2.457	2.498
	(0.814)	(0.816)	(0.859)	(0.862)	(2.238)	(2.177)
LINDEX	-0.689	-0.711	-0.845	-0.865	-0.932	-0.931
	(0.599)	(0.599)	(0.641)	(0.640)	(1.630)	(1.630)
GDPG	-0.008	-0.010	-0.047	-0.048	-0.104	-0.100
	(0.060)	(0.060)	(0.073)	(0.074)	(0.150)	(0.158)
INF	0.008	0.005	0.002	-0.001	0.100**	0.100**
	(0.013)	(0.013)	(0.014)	(0.014)	(0.043)	(0.043)
UM	0.002	0.002	-0.004	-0.003	0.003	0.004
	(0.014)	(0.014)	(0.016)	(0.016)	(0.044)	(0.045)
IQ	0.233**	0.203*	0.298**	0.268**	0.572*	0.565*
	(0.104)	(0.106)	(0.125)	(0.127)	(0.304)	(0.307)
Constant	0.816*	0.841*	1.102**	1.126**	-1.364	-1.381
	(0.474)	(0.476)	(0.510)	(0.512)	(1.456)	(1.479)

Table 7.
Alternative Digital Financial Inclusion (Continued)

	Full sample		Conventional banks		Islamic banks	
	Dependent variable: LZS					
	(1)	(2)	(3)	(4)	(5)	(6)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	27.707***	27.086***	26.166***	25.528***	10.791***	10.827***
Adjusted R-square	0.302	0.302	0.307	0.308	0.346	0.343
Observations	3167	3167	2839	2839	328	328

Clustered Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1*

4.6. Endogeneity and Sample Selection Bias

There may be potential reverse causality, where stability drives investment in digital finance, leading to higher DFI. While macro-level data help reduce endogeneity concerns, this study follows the approach of previous research (Ahamed & Mallick, 2019) and uses Two-stage least squares (2SLS-IV) and Propensity Score Matching (PSM) to address endogeneity and sample selection bias.

Table 8 presents the 2SLS-IV regression results. Based on the literature (e.g., Banna et al., 2021), 'the country-level share of mobile cellular subscriptions per 100 people' is used as an instrument. After instrumenting the baseline specifications of bank stability with the extent of digital financial inclusion, the results remain consistent.

Table 8.
2SLS-IV Regression

	Full sample			Conventional banks			Islamic banks		
	Dependent variable: LZS								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DFI	0.454***			0.484***			-0.542		
	(0.155)			(0.164)			(0.634)		
DFI × FIN_LIT_H		0.424***			0.444***			-0.368	
		(0.144)			(0.154)			(0.489)	
DFI × FIN_LIT_L			-0.070			0.003			-0.268
			(0.393)			(0.443)			(0.785)
LISTED	0.089	0.090	0.084	0.127	0.128	0.126	-0.084	-0.087	-0.091
	(0.074)	(0.074)	(0.075)	(0.080)	(0.080)	(0.080)	(0.202)	(0.202)	(0.201)
SIZE	0.196***	0.196***	0.195***	0.192***	0.191***	0.190***	0.258***	0.257***	0.250***
	(0.022)	(0.022)	(0.022)	(0.024)	(0.024)	(0.024)	(0.077)	(0.075)	(0.075)
IND	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***	-0.004	-0.004	-0.004
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)

Table 8.
2SLS-IV Regression (Continued)

	Full sample			Conventional banks			Islamic banks		
	Dependent variable: LZS								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LR	0.841***	0.835***	0.839***	0.865***	0.859***	0.867***	0.456	0.448	0.428
	(0.248)	(0.248)	(0.248)	(0.275)	(0.275)	(0.275)	(0.626)	(0.627)	(0.626)
LLPR	-35.304***	-35.205***	-35.214***	-34.819***	-34.739***	-34.813***	-37.086***	-37.459***	-37.377***
	(2.833)	(2.830)	(2.832)	(3.067)	(3.064)	(3.060)	(7.131)	(7.012)	(6.954)
MQ	1.114***	1.118***	1.094***	1.125***	1.130***	1.097***	1.591**	1.606**	1.620**
	(0.313)	(0.313)	(0.317)	(0.358)	(0.358)	(0.362)	(0.664)	(0.668)	(0.661)
CAP	3.683***	3.702***	3.733***	3.930***	3.953***	3.991***	2.743**	2.760***	2.769**
	(0.447)	(0.446)	(0.449)	(0.487)	(0.486)	(0.489)	(1.073)	(1.069)	(1.076)
HHI	0.270	0.237	-0.233	0.093	0.055	-0.407	0.898	1.228	1.729
	(0.701)	(0.699)	(0.683)	(0.743)	(0.741)	(0.726)	(1.925)	(1.773)	(1.558)
LINDEX	-1.401**	-1.468**	-1.535**	-1.296**	-1.360**	-1.388**	-1.592	-1.353	-1.183
	(0.567)	(0.571)	(0.598)	(0.612)	(0.619)	(0.648)	(1.812)	(1.699)	(1.718)
GDPG	-0.028	-0.030	-0.014	0.009	0.007	0.023	-0.036	-0.036	-0.052
	(0.041)	(0.041)	(0.042)	(0.048)	(0.048)	(0.048)	(0.066)	(0.067)	(0.068)
INF	0.003	0.002	0.004	-0.001	-0.002	0.001	0.050	0.052	0.048
	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.034)	(0.034)	(0.034)
UM	0.029**	0.028**	0.016	0.033**	0.031**	0.017	0.041	0.045*	0.046*
	(0.012)	(0.012)	(0.011)	(0.013)	(0.013)	(0.013)	(0.027)	(0.026)	(0.026)
IQ	0.008	0.016	0.141	0.031	0.043	0.181*	-0.003	-0.042	-0.131
	(0.097)	(0.096)	(0.091)	(0.106)	(0.105)	(0.100)	(0.303)	(0.292)	(0.260)
Constant	1.101***	1.146***	1.207***	1.035**	1.079**	1.129**	0.036	-0.123	-0.152
	(0.426)	(0.426)	(0.434)	(0.467)	(0.467)	(0.475)	(1.224)	(1.197)	(1.202)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chi-square	795.098***	793.755***	780.332***	717.473***	714.831***	698.268***	277.945***	271.632***	304.942***
Centred R-square	0.304	0.304	0.297	0.304	0.303	0.297	0.413	0.413	0.411
Observations	3261	3261	3261	2896	2896	2896	365	365	365

Clustered Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Additionally, a propensity score matching (PSM) technique, widely used in recent banking literature (e.g., Elnahass et al., 2021), is employed. We estimate the propensity scores of banks with higher than mean DFI (treatment group) compared to those with lower DFI (control group). Samples are matched using 1:1 nearest-neighbor matching without replacement. The results in Table 9 show that, across all specifications, digital financial inclusion significantly increases bank stability, and high financial literacy positively impacts this relationship.

Table 9.
Propensity Matching Score

	Full sample		Conventional banks		Islamic banks	
	Dependent variable: LZS					
	(1)	(2)	(3)	(4)	(5)	(6)
DFI	0.362***		0.490***		-1.562***	
	(0.138)		(0.148)		(0.511)	
DFI × FIN_LIT_H		0.360***		0.487***		-1.551***
		(0.138)		(0.148)		(0.509)
DFI × FIN_LIT_L		0.509		0.808		-1.836*
		(0.444)		(0.500)		(0.936)
LISTED	0.108	0.107	0.164**	0.164**	-0.266	-0.266
	(0.070)	(0.070)	(0.073)	(0.074)	(0.197)	(0.197)
SIZE	0.193***	0.193***	0.194***	0.194***	0.209***	0.207***
	(0.022)	(0.022)	(0.024)	(0.024)	(0.070)	(0.070)
IND	-0.008***	-0.008***	-0.010***	-0.010***	-0.004	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
LR	0.769***	0.768***	0.713**	0.711**	0.300	0.297
	(0.262)	(0.262)	(0.280)	(0.280)	(0.738)	(0.739)
LLPR	-42.262***	-42.277***	-42.246***	-42.268***	-38.243***	-38.162***
	(3.313)	(3.319)	(3.516)	(3.521)	(9.409)	(9.467)
MQ	1.244***	1.244***	1.188***	1.187***	2.321***	2.315***
	(0.366)	(0.366)	(0.406)	(0.406)	(0.833)	(0.832)
CAP	3.384***	3.381***	3.711***	3.704***	1.557	1.548
	(0.436)	(0.437)	(0.460)	(0.460)	(1.091)	(1.090)
HHI	0.251	0.246	0.556	0.545	-2.647	-2.626
	(0.778)	(0.780)	(0.893)	(0.895)	(1.775)	(1.787)
LINDEX	-0.318	-0.300	-0.416	-0.381	-0.760	-0.838
	(0.399)	(0.408)	(0.421)	(0.429)	(1.206)	(1.273)
GDPG	-0.096***	-0.095**	-0.093**	-0.090**	-0.046	-0.048
	(0.036)	(0.037)	(0.043)	(0.044)	(0.050)	(0.051)
INF	0.013	0.013	0.001	0.002	0.113***	0.112***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.031)	(0.030)
UM	0.013	0.013	0.021	0.022	0.004	0.003
	(0.014)	(0.015)	(0.016)	(0.016)	(0.029)	(0.030)
IQ	0.297***	0.298***	0.236***	0.238***	0.779***	0.781***
	(0.083)	(0.083)	(0.090)	(0.090)	(0.253)	(0.253)
Constant	0.539	0.525	0.694	0.667	-0.507	-0.420
	(0.467)	(0.472)	(0.501)	(0.506)	(1.366)	(1.388)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank Clustered	Yes	Yes	Yes	Yes	Yes	Yes
SE Clustered	Yes	Yes	Yes	Yes	Yes	Yes
F Statistics	29.771***	28.633***	28.148***	27.133***	15.002***	14.447***
Adjusted R-square	0.303	0.302	0.307	0.307	0.375	0.373
Observations	3028	3028	2701	2701	327	327

Clustered Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

V. CONCLUSION AND RECOMMENDATION

This study examines the relationship between digital financial inclusion (DFI), financial literacy, and bank stability, focusing on both conventional and Islamic banks across 15 countries from 2011 to 2020. For conventional banks, DFI, particularly on the demand side, significantly enhances bank stability by improving asset quality and reducing risks, consistent with existing literature that emphasizes the stabilizing effect of customer engagement with digital financial services. In contrast, the relationship between DFI and bank stability in Islamic banks is either insignificant or negative. The unique structure of Islamic finance, which mandates Shariah compliance, limits the effectiveness of DFI. Challenges such as mismatches between digital products and Islamic principles, competition from conventional banks and FinTech firms, and operational constraints hinder the positive impact of DFI on Islamic banks.

The interaction between high financial literacy and DFI shows a positive relationship with stability in conventional banks, as financially literate customers are more likely to engage with digital financial products, enhancing efficiency and profitability. However, for Islamic banks, this relationship is negative, as financially literate customers may be more cautious about digital services that do not fully align with Shariah principles, leading to lower adoption rates and reduced stability. These findings remain consistent across several robustness tests.

The results also align with lessons from recent events, such as the collapse of SVB, where rapid digital transactions and a mismatch between customer expectations and financial offerings exacerbated vulnerabilities. In Islamic banking, similar dynamics—such as digital products failing to meet religious principles or customer hesitancy towards non-compliant services—may weaken stability in the same way.

Based on these findings, several policy recommendations can be made. For conventional banks, policymakers should focus on increasing the active use of digital financial services by educating and encouraging customers to engage with these services. Infrastructure expansion alone is insufficient; targeted campaigns promoting digital banking and incentivizing usage are needed to improve bank stability. To address the negative or insignificant impact of DFI on Islamic banks, financial institutions should develop more Shariah-compliant digital products. These products must align with Islamic banking principles, adhering to profit-and-loss sharing, risk-sharing, and interest-free mechanisms. Islamic banks should innovate and offer digital solutions that meet their customers' needs while maintaining compliance with Shariah rules.

Given the positive interaction between financial literacy and DFI in conventional banks, central banks—such as Bank Indonesia, Bangladesh Bank, and Bank Negara Malaysia—should implement financial literacy programs focusing on digital financial services, particularly for underserved and rural populations. These programs should educate the public not only on basic financial principles but also on the benefits and safe use of digital services like mobile banking, e-wallets, and online investments. Special emphasis should be placed on Shariah-compliant financial literacy to ensure that Islamic bank customers understand how to navigate digital financial products that align with Islamic values. These

efforts would increase trust in digital services, promote financial inclusion, and enhance bank stability in the respective regions.

One limitation of this study is its reliance on existing datasets, which may not fully capture the nuances of digital financial inclusion and financial literacy across different regions, particularly in Islamic banking systems, where Shariah compliance plays a crucial role. The focus on quantitative proxies for DFI may overlook qualitative factors such as customer trust and cultural attitudes toward digital financial services. Additionally, the time frame and geographic scope may limit the generalizability of the findings to other regions or periods with different regulatory environments and technological advancements. Future research could address these limitations by incorporating qualitative analyses to explore customer perceptions of digital financial services, particularly in Islamic banking. Expanding the study to cover a broader range of countries and conducting longitudinal studies would also provide deeper insights into the evolving relationship between DFI, financial literacy, and bank stability over time.

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APPENDIX

Appendix A1: Pairwise Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) DFI	1.000														
(2) SA	0.767*	1.000													
(3) DU	0.943*	0.508*	1.000												
(4) SIZE	-0.179*	-0.196*	-0.139*	1.000											
(5) IND	-0.014	0.112*	-0.078*	0.060*	1.000										
(6) LR	0.086*	0.089*	0.069*	0.143*	-0.206*	1.000									
(7) LLPR	0.088*	0.066*	0.084*	-0.095*	-0.059*	0.133*	1.000								
(8) MQ	0.147*	0.201*	0.093*	0.225*	-0.071*	0.391*	-0.006	1.000							
(9) CAP	0.070*	-0.055*	0.123*	-0.425*	-0.144*	-0.172*	0.082*	-0.134*	1.000						
(10) HHI	-0.387*	-0.370*	-0.327*	0.044	0.039	-0.077*	-0.021	0.005	0.005	1.000					
(11) LINDEX	-0.038	-0.504*	0.211*	0.111*	-0.269*	0.146*	0.043	-0.031	0.187*	0.147*	1.000				
(12) GDPG	0.413*	0.485*	0.301*	-0.117*	0.038	0.110*	-0.002	0.080*	-0.084*	-0.508*	-0.249*	1.000			
(13) INF	-0.260*	-0.138*	-0.276*	-0.174*	0.126*	-0.199*	0.022	-0.296*	0.019	-0.012	-0.295*	-0.173*	1.000		
(14) UM	-0.399*	-0.239*	-0.410*	-0.119*	0.141*	-0.083*	-0.033	-0.262*	0.001	0.470*	-0.050*	-0.483*	0.296*	1.000	
(15) IQ	0.145*	-0.168*	0.282*	0.204*	-0.146*	0.217*	-0.061*	0.209*	0.030	0.246*	0.554*	-0.107*	-0.735*	-0.047*	1.000

*shows significance at the .01 level