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THE IMPACT OF DIGITAL FINANCIAL DEVELOPMENT ON COMMERCIAL BANK STABILITY

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Abstract

This study explores the relationship between digital financial development and the stability of commercial banks, focusing on how technological advancements and operational efficiency shape resilience in the financial sector. Using a dataset of 1,000 observations, the analysis examines pointers such as mobile banking usage, internet transfers, digital payments, and cost efficiency, while controlling for regional effects. The findings reveal that digital payments and operational efficiency pointedly boost bank stability, with efficiency emerging as the strongest determinant of resilience. In contrast, mobile banking adoption and internet transfers show positive but statistically insignificant effects, suggesting that their stabilizing role is still developing. Regional differences negatively impact steadiness, highlighting the importance of institutional and structural contexts. Furthermore, investigative tests confirm the presence of heteroskedasticity, indicating that mistake modification is thoroughly influenced by digital and regional factors. Overall, the learning concludes that while DFD supports financial stability, its assistances are unequally dispersed and extremely dependent on effectiveness, regulation, and regional readiness. The results underline the need for helpful rules, digital substructure investments, and financial literacy initiatives to maximize the possible of digital finance in promoting a stable and inclusive banking system.

Keywords: *Bank Stability, Mobile Banking, Digital Payments, Operational Efficiency, Regional Disparities, Financial Inclusion*

INTRODUCTION

The impression of bank stability has gradually become central to both academic and policy discussions in the aftermath of financial crises and the rapid evolution of the digital economy (Ali & Sajid, 2020; Ahmad & Alvi, 2024; Wim & Wendy, 2025; Iqbal & Noman, 2025). In this study, bank constancy is measured using the Z-score, a widely applied pointer that replicates the distance of a bank from insolvency by combining productivity, influence, and volatility (Čihák & Hesse, 2010). A higher Z-score specifies a more stable bank, signifying that it has stronger volume to absorb shocks and withstand financial distress, while an inferior score signals fragility and vulnerability (Ali, 2022; Soliman, 2025). Bank stability is not only a reflection of internal performance and effectiveness but is also formed by technical invention, working structures, and external macro-financial features (Omri, 2022; Khalid et al., 2025; Siddique et al., 2025; Mbodi & Laye, 2025; Mehdi et al., 2025). With the faster combination of digital financial facilities, the resilience of banks is no longer solely determined by traditional indicators such as return on assets or cost-to-income ratios but also by their capability to adjust to new skills and shifting buyer actions (Bozic & Bozic, 2025; Abbasi et al., 2025; Arshad et al., 2025; Ammar et al., 2025; Amir et al., 2025). Considering how digital financial development and operational effectiveness impact bank stability is thus important for both controllers and experts seeking to support the flexibility of the financial system (Ali & Rehman, 2015; Iqbal et al., 2025; Farras et al., 2025; Bukhari et al., 2025; Batool et al., 2025; Arshi et al., 2025; Dahmani & Makram, 2024). Among the needles of digital financial development, digital outflows as a ratio of GDP (DPGDP) serve as an indicator of the penetration and economic relevance of digital transactions. As economies shift from cash-based to cashless structures, digital outflows can decrease operational costs, improve transparency, and enlarge financial attachment, all of which can indirectly contribute to bank stability (Ozili, 2018; Zahid et al., 2025; Rafique et al., 2025; Umair et al., 2025). Similarly, internet transfers per 1,000 people (INTTR) indicate the amount of adoption of online financial services. Internet-based communications improve proficiency and availability, but their impact on bank stability is complex. While they may decrease working costs, they also expose banks to risks associated with cybersecurity and technical failures (Beck et al., 2016; Shaukat et al., 2025; Aman et al., 2025; Naeem et al., 2025; Ditta et al., 2025). An additional serious measurement of digital finance is the growth of mobile banking users (MBU). Mobile banking increases financial services to previously underserved people, enhancing client scope and profit prospects for banks. Simultaneously, it wants considerable investments in technology and infrastructure, which may strain banks, specifically in developed areas (Iqbal et al., 2025; Ali et al., 2025; Zafar et al., 2025; Ullah et al., 2025; Ali et al., 2025). Communally, this digital finance indicator's best part is the transformative role of technology in the financial division and its potential to affect the resilience and

performance of banks (Ali et al., 2025; Karim et al., 2025; Ali et al., 2025; Ali et al., 2025; Khalid et al., 2025; Ali et al., 2025).
In adding to digital finance, operational efficiency (OE) is an important element of bank stability. Operational efficiency replicates the ability of banks to diminish costs relative to income and to enhance resource distribution (Ali et al., 2025; Ali, et al., 2025; Aziz et al., 2025; Kanwal et al., 2025; Ahmad et al., 2025; Saim et al., 2025; Longston et al., 2025). An additional effective bank can improve absorb shockwaves, manage risks, and sustain productivity during times of uncertainty (Hasan et al., 2020; Rana et al., 2025; Hashmi et al., 2025; Ali et al., 2025; Abdullah et al., 2025; Ali et al., 2025; Kumar et al., 2025). Inefficiencies, instead, undermine competitiveness and expose banks to systemic vulnerabilities. Additionally, operational differences captured by the regional dummy (REG) play an important role in explaining variation in stability across banks. Regional differences may reflect transformations in institutional quality, regulatory frameworks, technological readiness, and economic growth, all of which condition how digital finance and efficiency explain into stability results (Ghosh, 2017; Ashraf et al., 2025; Khan et al., 2025; Aqeel et al., 2025; Arshad et al., 2025; Khan et al., 2025; Shahid et al., 2025; Shahi et al., 2025). By combining both digital and operational factors together with regional contexts, this study delivers a complete outline for understanding bank stability (Humza et al., 2025; Sattar et al., 2025). The relationship of these variables allows for a nuanced study of whether technological improvements and enhanced effectiveness translate into resilience or whether they create new forms of uncertainty in the banking sector.

LITERATURE REVIEW

Ozili et al. (2018) examine facts from 48 African states and find that digitalization improves banking productivity and stability by lowering cost-to-income percentages and non-performing loans. By means of the Z-score method, Ozili determines that digital financial tools contribute to resilience by promoting effective optimization and dropping revelation to loan defaults. These things are mostly evident in markets with high digital acceptance and helpful policy atmospheres. The results support the notion that digital operations, when integrated well, improve cost structures and credit concentration. Ozili emphasizes that technology adoption must be planned and complete to realize its full potential. Furthermore, the learning shows that digital finance supports cushion banks compared to external shocks by enabling flexible and adaptive responses. Universal, the study reinforces the fight that digital transformation, especially when guided by effective regulation, plays a vibrant role in strengthening financial stability in evolving economies.
Banna et al. (2021) reinforced the connection between digital financial inclusion and banking sector stability, mostly within the ASEAN area, during and after the COVID-19 pandemic. Their study on Islamic banks across 32 countries exposes that financial technologies, when used to increase inclusion, significantly expand operational efficiency and decrease market risks. These results are mostly relevant during economic shocks, where resilient banking systems are important. Digital finance tools, by spreading access to official financial services, empower more people and businesses to interact safely and professionally with the financial system. Banna and Alam claim that this inclusivity supports broader macroeconomic stability by spreading risk and reducing dependency on informal financial channels. Their decisions highlight that DFD must be integrated into national development strategies. Appropriately directed digital finance, they contend, is not just a tool for creation but a critical tool for certifying long-standing banking and financial system resilience across diverse economies.
Feghali et al. (2021) inspected how digital inclusion contributes to banking stability by increasing payments and portfolio variety. Their study shows that digital platforms help formalize savings and investment activities, particularly among underserved people. Though they caution that digital lending without difficult credit valuations can introduce systemic risks. The double nature of digital finance, its ability to both stabilize and destabilize, depends on the worth of official oversight. Feghali et al. highlight that healthy controlling frameworks are important to mitigate these risks. Without adequate controls, quick digital growth can lead to unchecked credit development, rising default risks, and threatening stability. The writers claim that inclusion must be balanced with prudence, especially in economies where financial literacy and institutional capacity may be limited. Therefore, although digital inclusion is dynamic for financial development, it should not come at the expense of financial health. Their study underlines the importance of governance in navigating DFD's complex effects.
Nguyen et al. (2021) warned that aggressive digital growth into fee-formed, non-interest income services can lead to failure of bank stability. Their outcomes show that digital platforms can drive extreme adjustment, exposing banks to higher operational and strategic risks. Similarly, Cuadros-Solas et al. (2024) claim that FinTech lending platforms erode traditional banks' market shares, thereby increasing opposition and theoretically destabilizing the

area. These growths lead to compressed profit margins and heightened systemic vulnerabilities, especially in markets with deficient regulatory robustness. Nguyen et al. suggest that while DFD enables revenue generation through new networks, these must be followed carefully. Cuadros-Solas et al. emphasize the need for regulatory frameworks to manage the growing influence of non-bank digital lenders. Both revisions demonstrate the double-edged nature of the digital financial revolution. As banks strive to update and stay inexpensive, unregulated or unwell, allied DFD extension can pose risks that challenge the very stability these technologies promise to improve.
Jungo et al. (2022) likened the properties of DFD on banking stability across Latin America and Sub-Saharan Africa. Their results disclose that digital financial inclusion improves stability when supported by sound regulatory frameworks. Though in unregulated atmospheres, DFD may boost extreme competition and risk-taking, eroding profit margins and increasing systemic vulnerability. Jungo et al. warn that digital rivalry must be balanced with financial prudence to avoid destabilization. They maintain that region-specific regulations account for institutional sizes and economic circumstances. Their study highlights the position of policy direction in ensuring that DFD strengthens slightly rather than challenges the banking sector. The difference between the two regions also proves that the benefits of DFD are not automatic but depend on recognized willingness and regulatory placement. So, though DFD holds promise for inclusive financial development, its achievement is conditional upon effective oversight and the arrangement of digital creativities with national financial stability areas.
Antwi et al. (2023) provided evidence that internet-based digital finance stages increase financial stability in rising economies. Their study, conducted across 55 countries, specifies that while internet usage absolutely impacts financial stability, mobile phone subscriptions may exert a negative influence. This dichotomy suggests that not all forms of digital finance have uniform outcomes. Internet access supports broader financial inclusion and institutional resilience, whereas mobile technologies can present new threats if not attended by passable credit valuations and regulation. Antwi and Kong advocate for targeted policy responses that report the specific dynamics of digital technology acceptance. Their effort also underlines the reputation of structural readiness and institutional volume in management digital transitions. The practical indication provided exposes that the separated impacts of DFD must be known in designing financial and governing policies. This double impact of DFD gears reinforces the necessity of granular policy frameworks aligned with the unique needs of developing financial systems.
Wang et al. (2023) argued that digital automation in finance reduces labor costs and improves compliance through standardized reporting and monitoring systems. Their findings reveal that DFD tools improve efficiency and simplify governing procedures. (Luo et al. 2023) accompany this with a presentation that big figures and advanced analytics improve credit risk estimations and facilitate real-time danger monitoring. These technological improvements reorganize internal controls and improve decision-making procedures. In the meantime, Mavlutova et al. (2022) highlight buyer pleasure, noting that digital finance increases service availability and allows modified contributions, which support buyer loyalty and financial enclosure. Altogether, these studies advise that DFD helps both inside operative profits and exterior buyer engagement. Though they also suggest that technology alone is not enough, its efficiency depends on the combination of administrative culture and regulatory environments. The mutual impact of automation, analytics, and personalization affirms the transformative possibilities of DFD in making effective, compliant, and buyer-centric banking structures.
Zhou & Liao (2024) highlighted that digital financial development is necessarily transforming universal banking by leveraging inventions such as mobile payments, blockchain, and artificial intelligence. Their study proves that DFD significantly improves financial inclusion, functioning proficiency, and organized stability by enhancing availability and operational speed. The writers argue that digital tools are essential to revolutionizing old financial systems, mainly by making services more comprehensive and resilient. DFD not only decreases the rate of financial services but also fosters real-time numbers processing and broader outreach. Zhou and Liao complete that participating in such technologies positions commercial banks to operate more competitively and strongly in a progressively digital, comprehensive economy. Their insights provide the basis for understanding how digital tools act as equally enablers and protections for financial structures, particularly when used in combination with solid regulatory error and infrastructure development in both developed and developing markets.
Zeqiraj et al. (2024) linked digital financial development to enhancements in return on assets (ROA) and return on equity (ROE), highlighting how DFD boosts these performance indicators by reducing inefficiencies. Their study emphasizes Southeast Europe and emphasizes the role of digital infrastructure in attracting effectiveness and constancy. Zeqiraj et al. also classify a gap in the literature, noting that many lessons fail to consider how technological readiness and infrastructure value affect DFD results. Their findings advise that investments in

digital infrastructure, such as safe internet access and cloud-based banking structures, are essential to active DFD implementation. Furthermore, the writers argue that financial institutions must align their digital strategies with larger economic development goals. By linking profitability with technological effectiveness, this research highlights how DFD contributes not only to individual bank performance but also to system-wide resilience in developing areas.

Ruan et al. (2024) highlighted that digital financial tools cut credit risk by empowering better data analytics and more correct credit valuations. They find that machine knowledge and AI-driven tools allow banks to calculate borrower performance more precisely, which decreases default charges and improves stability. Likewise, Hao et al. (2023) prove that DFD affects liquidity management in nuanced ways. Their study discloses that whereas digital finance may decrease on-balance sheet liquidity due to an alteration in operational dynamic forces, it does not knowingly impact off-balance sheet events. These results advise that the DFD technologies' requirements be evaluated according to a specific banking system. Ruan and Jiang's investigation supports the idea that risk mitigation through digital transformation is probable, but it requires calculated alignment. Combined with Hao et al.'s liquidity conclusions, the research explains the diverse pathways through which digital tools affect financial processes. This range mandates tailored strategies for successful DFD application in banking.

Alvi et al. (2024) find that digital banking in South Asia recovers liquidity, grows deposits, and decreases reliance on external funding, contributing to financial stability. Their study reveals that DFD supports credit growth by confirming consistent and local capital movements. Though they argue that these profits are exploited only when digital finance aligns with comprehensive development rules. Alvi et al. recommend that governments and banks manage efforts to confirm that digital finance tools reach underserved communities without negotiating creditworthiness. The study shows that DFD can act as a connection to financial inclusion, but only when corresponding with regulatory guidance, infrastructure investment, and financial knowledge. Their results underscore the importance of integrating digital tools into broader economic development plans. By focusing on liquidity and credit spreading, Alvi et al. provide a real outline for leveraging digital finance to foster both institutional stability and inclusive development in the emerging world.

Bozic et al. (2025) recognized digital invention as a significant internal and external factor prompting financial stability. Their study suggests that the effective implementation of DFD depends not only on the convenience of technology but also on skilled people and strong regulatory outlines. They discovered that banks with clear digital strategies and skilled staff are better positioned to manage developing digital risks, including cyber threats and credit scams. Additionally, the presence of supportive institutional structures improves the risk-mitigating potential of DFD. The authors argue that DFD is not merely a technical elevation but a strategic imperative that needs holistic organization. Digital revolution is essential to be aligned with governance buildings, employee training, and sector-wide policy direction. Bozic and Bozic thus place DFD as a crucial determinant of financial resilience, especially in rapidly evolving banking environments. Their study calls for cooperative efforts among regulators, financial institutions, and instructors to fully realize the stabilizing potential of digital finance.

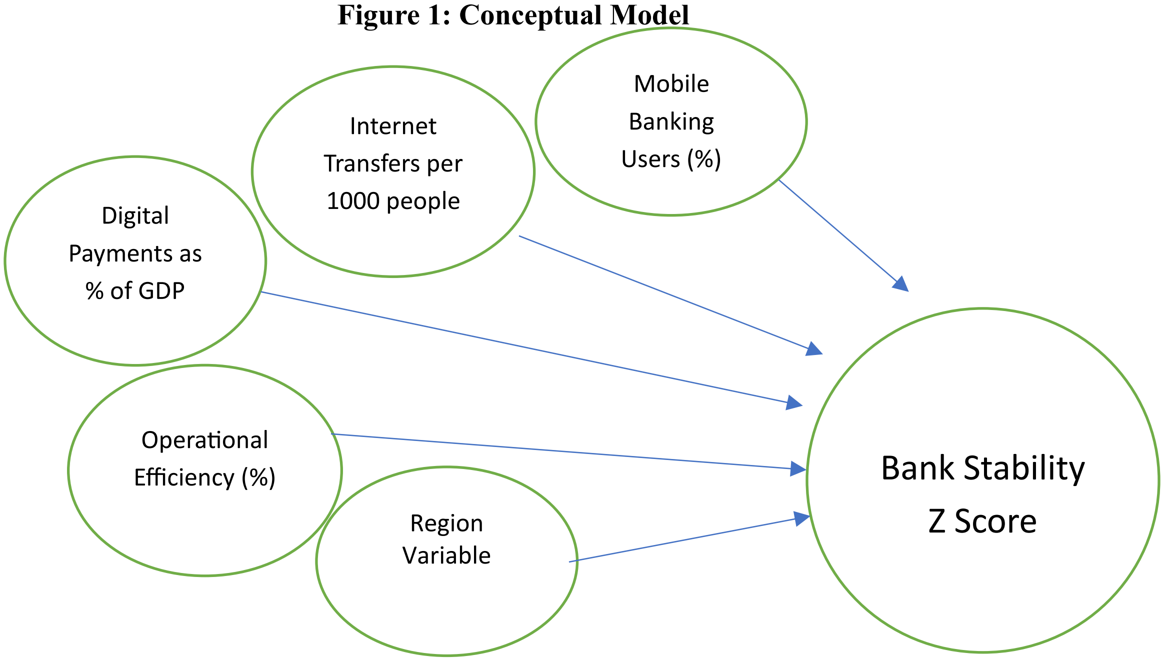
Liang et al. (2025) find that DFD pointedly improves bank profitability and considers risk-taking, both of which enhance financial stability. Utilizing information from Chinese commercial banks, the study identifies effective efficiency as a key mediator in the DFD stability connection. Their results reveal that technology acceptance streamlines procedures, cuts costs, and improves the performance of banking institutions. As productivity grows and risk is managed successfully through digital tools, banks become more resilient to market shocks and volatility. Liang et al. assert that DFD plays a calculated role in fostering sustainable and competitive banking practices in developing economies. Likewise, their investigation confirms that efficient implementation of DFD tools not only recovers financial health but also supports risk management frameworks. This positions digital transformation as an essential support in recent banking strategy, especially amid growing buyer hopes and economic doubt. Therefore, their research confirms DFD's serious value for long-term banking stability.

THEORETICAL MODEL

The development of digital finance has transformed the banking division by restructuring outdated financial intermediation procedures. According to the Financial Mediation Theory, Diamond & Dybvig (1983), banks play an essential part in directing funds from investors to debtors while managing risks and decreasing transaction costs. With improvements such as mobile banking, online lending platforms, blockchain technologies, and digital wallets, banks are now leveraging digital tools to enhance productivity and buyer convenience. These technologies smooth quicker transactions, upgraded credit calculation, and real-time monitoring of financial activities, all of which contribute to the stability of banking institutions (Kanwal et al., 2025; Ahmad et al., 2025; Sabir et al., 2025; Niaz et al., 2025; Khan et al., 2025; Ghauri et al., 2025). However, while digitalization offers chances for improved financial enclosure and operational resilience, it also introduces new challenges such as cybersecurity risks, data privacy concerns, and regulatory gaps. Integrating the Technology Acceptance Model (Davis, 1989) into this framework highlights that the positive acceptance of digital financial tools depends on their perceived usefulness and ease of use by both banks and their buyer. Organizations that foster confidence and user-friendly technologies are more likely to achieve widespread recognition, strengthening their competitive benefit and financial stability.

Rogers' Diffusion of Innovation Theory (2003) additionally supports this model by explaining how technological modernizations spread within organizations and the world. Banks' acceptance of digital inventions often follows an S-curve design, with innovators and initial adopters setting the pace before reaching the majority. This uneven diffusion can lead to gaps in stability consequences between larger banks with greater technological resources and smaller institutions with restricted digital capabilities (Qaisrani et al., 2025; Ali et al., 2025; Ahmad et al., 2025; Khalil et al., 2025). Furthermore, the combination of digital finance with operational efficiency theories suggests that improved asset consumption, cost reductions, and procedure automation mediate the connection between digital finance development and bank stability (Nasir et al., 2025; Anus et al., 2025). As proved by Liang et al. (2025), banks with advanced levels of digital maturity demonstrate stronger productivity, improved risk-bearing capacity, and better resilience to financial shocks. Therefore, this hypothetical model suggests that digital finance development, mediated by operational efficiency and moderated by institutional capacity (such as size and regional infrastructure), leads to upgraded bank stability. The effective arrangement of these theoretical perspectives underlines the importance of strategic digital acceptance and robust governance frameworks to ensure sustainable financial sector expansion.

Figure 1: Conceptual Model



Based on conceptual model, the mathematical model of our study become as:

$BSZit = \alpha + \beta1\ MBUit + \beta2\ INTTRit + \beta3\ DPGDPit + \beta4OEit + \beta5REGit + \epsilon it$

Where:

- BSZit = Bank Stability Z-Score for bank *i* at time *t* (Dependent Variable)
- MBUit = Mobile Banking Users (%)
- INTTRit = Internet Transfers per 1000 people
- DPGDPit = Digital Payments as % of GDP
- OEit = Operational Efficiency (%)
- REGit = Region Dummy Variable (Control)
- α = Constant term
- β1…β5 = Coefficients to be estimated

- ϵit = Error term

Table 1: Variable Definitions, Measurement, and Sources

Variable	Short Code	Definition	Measurement	Source
Bank Stability (Z-Score)	BSZ	An indicator of bank stability and distance to default.	$\frac{ROA+(Equity/Assets)}{\sigma(ROA)}$	World Bank – *Global Financial Development Database (GFDD)*, IMF, BankScope, Orbis Bank Focus
Mobile Banking Users (%)	MBU	Share of population using mobile banking services.	% of the adult population with a registered mobile banking account	World Bank – *Global Findex Database*, GSMA Mobile Money Statistics
Internet Transfers per 1000 people	INTTR	Internet-based banking transactions relative to the population.	Number of online transfers per 1000 people annually	Central Banks, IMF Financial Access Survey, World Bank
Digital Payments as % of GDP	DPGDP	Value of digital transactions relative to GDP.	(Value of digital payments ÷ GDP) × 100	World Bank – *Global Findex*, IMF Payment Systems Database, Central Banks
Operational Efficiency (%)	OE	A measure of cost management and efficiency in banking operations.	Common proxies: (1) Cost-to-Income Ratio, (2) Asset Turnover	IMF Financial Soundness Indicators (FSI), Banks' Annual Reports
Region Variable	REG	Dummy variable capturing region-specific effects.	Binary coding: 0 = Base region, 1 = Other region(s)	Constructed by a researcher based on country/region classification

RESULTS AND DISCUSSION

The expressive statistics of the designated variable quantity provide useful insights into their distribution and variability across the sample of 1,000 observations. The mean and median values for Bank Stability (BSZ) are almost matching, suggesting a balanced spread with no main skewness. Similarly, the digital finance indicators—Digital Payments as a percentage of GDP (DPGDP), Internet Transfers per 1,000 people (INTTR), and Mobile Banking Users (MBU)—as well as Operational Efficiency (OE), also show relatively close mean and median values, indicating symmetrical distributions. All variables are scaled between 0 and 1000, with standard deviations ranging from approximately 282 to 306, reflecting moderate variability in the dataset. The Region dummy variable is evenly distributed between 0 and 1, as shown by its mean and median of 0.5 and standard deviation of 0.5, ensuring balance across regional classifications. Skewness values for all continuous variables are close to zero, while kurtosis values remain below three, suggesting flatter-than-normal (platykurtic) distributions with lighter tails. However, the Jarque–Bera statistics are significant with probabilities equal to zero, confirming that none of the variables follow a perfect normal distribution. This departure from normality is expected due to the bounded scaling of the data and the binary nature of the Region variable. Overall, the descriptive analysis highlights that the dataset is fairly symmetric and exhibits moderate variation, making it suitable for econometric analysis, though the violation of normality assumptions indicates the need for robust estimation techniques in subsequent modeling.
The correlation matrix highlights the relationships among bank stability (BSZ), digital financial development indicators, operational efficiency (OE), and control variables. Bank Stability (BSZ) shows a weak but positive association with Digital Payments as a percentage of GDP (DPGDP, 0.0524), Internet Transfers (INTTR, 0.0069), and Mobile Banking Users (MBU, 0.0332), suggesting that digital financial development may contribute marginally to stability, although the strength of the relationship is very small. A more notable finding is the

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moderate positive correlation between BSZ and Operational Efficiency (0.2048), indicating that efficiency improvements are associated with higher bank stability. Interestingly, BSZ is negatively correlated with the Region dummy (–0.0843), implying that regional differences may affect stability outcomes, with some regions experiencing relatively weaker stability.

Table 2: Descriptive Statistics

	BSZ	DPGDP	INTTR	MBU	OE	REG
Mean	458.3677	514.1958	514.6113	492.6451	532.3604	0.5
Median	458.42	471.07	574.705	468.2	539.16	0.5
Maximum	1000	1000	1000	1000	1000	1
Minimum	0	0	0	0	0	0
Std. Dev.	282.3078	304.3272	287.1615	297.8828	305.665	0.50025
Skewness	0.203619	0.103165	-0.1509	0.194594	-0.099339	0
Kurtosis	1.975817	1.729942	1.868059	1.746517	1.655948	1
Jarque-Bera	50.61642	68.9842	57.18223	71.77863	76.91453	166.6667
Probability	0	0	0	0	0	0
Sum	458367.7	514195.8	514611.3	492645.1	532360.4	500
Sum Sq. Dev.	79618005	92522410	82379277	88645430	93337678	250
Observations	1000	1000	1000	1000	1000	1000

Among the independent variables, DPGDP has a positive correlation with both INTTR (0.1219) and REG (0.1237), suggesting that greater digital payment activity is linked to higher internet-based transactions and varies across regions. INTTR also shows a positive correlation with REG (0.1580), reinforcing the role of regional factors in shaping digital adoption. On the other hand, MBU shows small negative correlations with DPGDP, INTTR, and REG, indicating that mobile banking adoption may not move in tandem with other digital financial indicators in this dataset. The correlations between YEAR and other variables are very weak, with values close to zero, implying no significant time trend effect in the correlations. Overall, the correlation results suggest that while digital finance indicators have weak direct linkages with bank stability, operational efficiency emerges as a stronger determinant. Regional factors also appear to play a role in influencing both digital finance adoption and stability, highlighting the importance of controlling for regional heterogeneity in further analysis.

Table 3: Correlation Matrix

	BSZ	DPGDP	INTTR	MBU	OE	REG	YEAR
BSZ	1						
DPGDP	0.0524043	1					
INTTR	0.0069825	0.1219158	1				
MBU	0.0332599	-0.041013	-0.007345	1			
OE	0.2048199	-0.027421	0.0187321	0.008726	1		
REG	-0.084282	0.1237489	0.1580598	0.096487	0.0149733	1	
YEAR	0.0240048	0.1112762	-0.065728	0.042036	-0.012112	0	1

The unit root test results provide insights into the stationarity of the study variables under different specifications. At the level form, the results are mixed. The Levin, Lin & Chu (LLC) test shows that variables such as INTTR (–6.17) are stationary without a trend, while others like DPGDP, MBU, OE, and REG report large positive LLC statistics, indicating non-stationarity under this approach. However, the Im, Pesaran, and Shin (IPS), ADF-Fisher, and PP-Fisher tests show stronger evidence of stationarity for most variables at the level, particularly for INTTR, MBU, OE, and REG. This inconsistency between the LLC and other tests suggests that stationarity may depend on whether a common or individual unit root process is assumed across cross-sections. At the first difference, the results are consistent across all tests. Both LLC and IPS statistics become strongly significant, with large negative values for DPGDP, INTTR, MBU, OE, and REG, while ADF-Fisher and PP-Fisher tests also reject the null of a unit root. This confirms that all variables are stationary after first differencing, meaning they are integrated of order one, I(1).

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Table 4: Unit Root Tests Results

At level without time trend					At level with time trend				
Variables	LLC	IPS	ADF-Fisher	PP-Fisher	LLC	B t-stat	IPS	ADF-Fisher	PP-Fisher
DPGDP	8.9459	-6.79683	59.042	312.421	12.6518	0.49386	-6.41539	50.0034	526.782
INTTR	-6.1725	-11.9633	145.437	294.863	-8.73782	-1.99181	-12.1097	152.786	526.782
MBU	63.2325	-8.29238	82.4451	186.281	89.4375	0.20702	-8.07043	74.9956	526.782
OE	63.9881	-5.91423	47.2159	349.556	90.5118	0.28862	-5.44684	38.3647	526.782
REG	24.514	-7.52507	70.0099	231.228	34.6835	-1.22703	-7.22044	61.4364	337.319
At first difference without time trend					At first difference with time trend				
Variables	LLC	IPS	ADF-Fisher	PP-Fisher	LLC	B t-stat	IPS	ADF-Fisher	PP-Fisher
DPGDP	299.951	-10.526	115.76	36.8414	424.304	0.46165	-10.5337	109.992	36.8414
INTTR	736.518	-15.6907	201.022	36.8414	1041.85	0.6775	-16.2358	225.425	36.8414
MBU	746.258	-16.8629	215.926	36.8414	1055.62	0.35951	-17.5298	252.005	36.8414
OE	643.755	-17.9864	227.385	36.8414	910.602	0.52012	-18.7699	276.018	36.8414
REG	216.634	-6.41024	45.8143	18.4207	30.9222	0.13839	-15.9503	219.534	281.811

The consistency of results with and without time trends at the first difference level further strengthens this conclusion. Overall, these findings indicate that while some digital finance indicators, such as internet transfers, show evidence of stationarity at the level, most variables require first differencing to achieve stationarity. This justifies the use of econometric techniques that account for I(1) variables, such as panel cointegration and dynamic panel models, to properly capture the long-run and short-run relationships among bank stability, digital financial development, operational efficiency, and regional characteristics.

The regression results with Bank Stability (BSZ) as the dependent variable provide important insights into the effects of digital financial development, operational efficiency, and regional differences. Among the digital finance variables, Digital Payments as a percentage of GDP (DPGDP) has a positive and statistically significant coefficient (0.0624, $p = 0.0328$), indicating that an increase in digital payment activity contributes to greater bank stability. However, Internet Transfers (INTTR) and Mobile Banking Users (MBU) show positive but statistically insignificant coefficients, suggesting that while they move in the expected direction, their impact on stability is weak or not robust in this model. Operational Efficiency (OE) emerges as the strongest determinant, with a highly significant positive effect (0.1925, $p < 0.01$), meaning that banks with better cost management and resource utilization enjoy higher stability. On the other hand, the Region dummy (REG) shows a significant negative effect (–53.42, $p = 0.0028$), highlighting that banks in certain regions experience systematically lower stability compared to others, possibly due to structural or institutional differences. The time trend variable (YEAR) and the constant term are both statistically insignificant, suggesting no clear time trend in bank stability over the sample period.

In terms of model fit, the R-squared value of 0.0558 indicates that about 5.6% of the variation in bank stability is explained by the included variables, which is modest but acceptable for cross-sectional/panel-type financial data. The overall model is statistically significant (F-statistic = 9.77, $p < 0.01$), and the Durbin–Watson statistic of 1.83 suggests no major autocorrelation issues. Taken together, the results emphasize that digital payments and operational efficiency are key drivers of stability, while regional disparities reduce stability, and other digital indicators (INTTR, MBU) do not yet have a significant direct influence in this dataset.

Table 5: Least Squares

Dependent Variable: BSZ				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DPGDP	0.062446	0.02922	2.137096	0.0328
INTTR	0.011244	0.030974	0.363015	0.7167
MBU	0.028121	0.029399	0.956535	0.339
OE	0.192459	0.028503	6.752188	0
REG	-53.4294	17.80374	-3.001021	0.0028
YEAR	5.309271	7.862589	0.675257	0.4997
C	-10407.12	15902.31	-0.654441	0.513
R-squared	0.05576	Mean dependent var		458.3677
Adjusted R-squared	0.050055	S.D. dependent var		282.3078
S.E. of regression	275.1517	Akaike info criterion		14.0795
Sum squared resid	75178513	Schwarz criterion		14.11385
Log likelihood	-7032.749	Hannan-Quinn criter.		14.09255
F-statistic	9.773217	Durbin-Watson stat		1.830255
Prob(F-statistic)	0			

The Breusch–Pagan–Godfrey heteroskedasticity test results show clear evidence of heteroskedasticity in the regression model. The F-statistic (15.27, $p < 0.01$), Obs*R-squared (84.48, $p < 0.01$), and Scaled explained SS (46.17, $p < 0.01$) are all highly significant, leading to rejection of the null hypothesis of homoskedasticity. This means that the variance of the residuals is not constant across observations but instead depends on one or more explanatory variables. In practical terms, the presence of heteroskedasticity does not bias the coefficient estimates themselves, but it does make the standard errors unreliable, which in turn can distort t-statistics and p-values. As a result, some variables may appear significant (or insignificant) purely because of biased error variances. To address this issue, it is advisable to use robust (heteroskedasticity-consistent) standard errors, such as White's correction, or employ generalized least squares (GLS) methods. This adjustment will ensure valid hypothesis testing and more reliable inference, allowing the results to reflect the true impact of digital finance, operational efficiency, and regional factors on bank stability.

Table 6: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	15.27134	Prob. F(6,993)	0
Obs*R-squared	84.47878	Prob. Chi-Square(6)	0
Scaled explained SS	46.16762	Prob. Chi-Square(6)	0

The Harvey heteroskedasticity test results confirm the presence of heteroskedasticity in the regression model. The F-statistic (7.46, $p < 0.01$), Obs*R-squared (43.15, $p < 0.01$), and Scaled explained SS (37.93, $p < 0.01$) are all highly significant, leading to rejection of the null hypothesis of homoskedasticity. Unlike the Breusch–Pagan test, the Harvey test specifically assumes that the error variance is related to the fitted values in a multiplicative or exponential form. The significant results here suggest that the residual variance systematically changes with the level of predicted values or explanatory variables, indicating a strong form of heteroskedasticity. In practical terms, this finding reinforces the conclusion that the residuals are not evenly distributed, which makes ordinary least squares (OLS) standard errors inefficient and unreliable for hypothesis testing. Although the coefficient estimates remain unbiased, the significance tests may be misleading. To ensure robust inference, it is necessary to apply heteroskedasticity-consistent standard errors (robust SEs) or alternative estimation techniques such as generalized least squares (GLS) or fixed/random effects models with robust corrections. This adjustment will correct for the non-constant variance and provide more trustworthy results when analyzing the impact of digital finance and operational efficiency on bank stability.

Table 7: Harvey

Heteroskedasticity Test: Harvey			
F-statistic	7.464206	Prob. F(6,993)	0
Obs*R-squared	43.15463	Prob. Chi-Square(6)	0
Scaled explained SS	37.92913	Prob. Chi-Square(6)	0

The White heteroskedasticity test results indicate strong evidence of heteroskedasticity in the model. The overall statistics—F-statistic (22.95, $p < 0.01$), Obs*R-squared (370.68, $p < 0.01$), and Scaled explained SS (202.58, $p < 0.01$)—are all highly significant, leading to the rejection of the null hypothesis of homoskedasticity. This means the variance of the error terms is not constant and is systematically related to combinations of the explanatory variables. Looking at the auxiliary regression, several interaction terms are significant, showing how heteroskedasticity arises in this model. For example, the squared term $DPGDP^2$ has a positive and highly significant coefficient (0.31, $p < 0.01$), indicating that the variance of the residuals increases with the magnitude of digital payments, i.e., higher levels of digital payments are associated with more variability in stability outcomes. The interaction DPGDP × INTTR is also positive and significant (0.09, $p < 0.01$), suggesting that the joint effect of digital payments and internet transfers contributes to heteroskedasticity. Similarly, DPGDP × REG is negative and significant (–59.21, $p < 0.01$), implying that the variance of errors differs systematically across regions when combined with digital payment activity. By contrast, other interaction terms, such as DPGDP × MBU, DPGDP × OE, and DPGDP × YEAR, are statistically insignificant, meaning they do not contribute significantly to error variance. In sum, the White test confirms that heteroskedasticity in the model is driven particularly by nonlinear effects of digital payments ($DPGDP^2$) and its interactions with internet transfers and regional factors. While the coefficients in the main regression remain unbiased, the presence of heteroskedasticity makes the standard errors unreliable. To address this, robust (heteroskedasticity-consistent) standard errors should be applied, ensuring valid inference regarding the impact of digital finance and operational efficiency on bank stability.

Table 8: White

Heteroskedasticity Test: White				
F-statistic	22.94817	Prob. F(25,974)		0
Obs*R-squared	370.6808	Prob. Chi-Square(25)		0
Scaled explained SS	202.5769	Prob. Chi-Square(25)		0

The overall results provide valuable insights into the role of digital financial development and operational efficiency in shaping bank stability. The descriptive analysis shows that the dataset is balanced and fairly symmetric, though not perfectly normal, which justifies the application of robust estimation techniques. The correlation matrix highlights that operational efficiency is more strongly associated with stability than digital finance indicators, while regional disparities appear to reduce stability. The unit root tests confirm that most variables are integrated of order one, I(1), which supports the use of econometric techniques that account for non-stationarity. Regression findings reveal that digital payments and operational efficiency significantly enhance bank stability, whereas internet transfers and mobile banking usage, although positive, have no robust effect. Regional differences remain a challenge, as indicated by the negative and significant regional coefficient. Importantly, diagnostic tests—including Breusch–Pagan, Harvey, and White—consistently confirm the presence of heteroskedasticity, implying that the variance of errors is not constant and is influenced by factors such as digital payment activity and regional characteristics. This strengthens the need for robust or generalized estimation methods to ensure valid inference. Taken together, the evidence suggests that while digital finance contributes to stability, its benefits are uneven across regions, and operational efficiency remains a critical driver of resilient banking systems.

CONCLUSIONS

This study provides important insights into the evolving relationship between digital financial development (DFD) and commercial bank stability, showing that while technology brings immense opportunities for strengthening resilience, its benefits are not uniformly distributed. The results highlight that digital payments significantly contribute to stability by improving transaction efficiency and expanding financial access. Additionally, operational competence emerges as the strongest determinant of bank resilience, suggesting that technological tools alone are inadequate unless accompanied by actual cost management, strong governance, and institutional willingness. In contrast, mobile banking usage and internet transfers, though they display positive relations, did not yield statistically important effects. This result specifies that some digital channels are still in a formative stage and may involve further maturity, bigger acceptance, and improved regulation before they can meaningfully strengthen financial stability. An outstanding finding of this study is the role of regional disparities in shaping stability outcomes. The negative impression of regional transformations demonstrates that not all markets are equally prepared to harness the benefits of digital finance. In regions with underdeveloped infrastructure, weaker governing oversight, or lower levels of financial knowledge, digital tools may fail to reach their potential or may even introduce risks that undermine bank stability. This underscores the need for policymakers to adopt tailored, region-specific strategies rather than one-size-fits-all methods. Investment in digital infrastructure, synchronized regulatory frameworks, and capacity building are critical to confirm that the advantages of digital finance are broadly shared and do not exacerbate financial inequalities across areas.

The occurrence of heteroskedasticity in the findings further reinforces the complication of the relationship between digital finance and stability. The evidence recommends that variations in error variance are systematically connected to digital activity and regional factors, meaning that the influence of DFD cannot be fully captured without robust estimation techniques. This procedural insight emphasizes the importance of adopting advanced econometric methods when studying financial transformations. By accounting for these statistical realities, the study confirms more consistent inferences that reflect the true dynamics of how digitalization interacts with financial stability.

From a policy viewpoint, the suggestions are clear: digital finance can be a powerful enabler of stability, but its success is contingent on strategic configuration with effectiveness measures and institutional capacity. Regulators and governments should rank the development of comprehensive digital ecosystems by investment in secure payment infrastructures, endorsing financial literacy, and confirming strong oversight of digital borrowing and payment platforms. Banks, on their part, must integrate digital tools into broader effective strategies, certifying that technology enhances, not alternatives to, sound financial management. The success of digital transformation lies not only in implementing cutting-edge technologies but in implementing them within effective, well-governed, and buyer-focused institutions.

In conclusion, digital financial development is a double-edged sword for commercial bank stability. It is possible to enhance resilience by improving effectiveness, expanding access, and reducing operational costs. All at once, if not appropriately regulated or aligned with functioning efficiency, it can present vulnerabilities, deepen regional divisions, and decline systemic stability. The results of this study call for a stable approach, one that harnesses the promise of digital finance while protecting against its risks. By positioning digital innovations with strong institutional frameworks and regionally tailored policies, the financial sector can build a future that is both technically advanced and essentially stable. Such a trajectory will not only support the banking system but also foster comprehensive economic growth and resilience in a progressively digital worldwide economy.

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