The Effect of Digital Financial Inclusion on the Profitability of Jordanian Commercial Banks

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Abstract

Purpose — This study examines the relationship between digital financial inclusion (DFI) and the profitability of Jordanian commercial banks, while testing operational efficiency as a transmission mechanism and bank resources as boundary conditions. Design/methodology/approach — The analysis covers 12 Jordanian domestic conventional commercial banks over 2015–2024, yielding 120 bank-year observations. A multidimensional DFI index combines digital access, usage, affordability, and service quality/responsible inclusion. Two-way fixed-effects models are estimated for return on assets (ROA), return on equity (ROE), and net interest margin (NIM). Inference is based on bank-clustered standard errors and is reassessed using a wild-cluster bootstrap. Alternative index constructions, a one-year lag, pandemic-year exclusions, mediation analysis, moderation tests, and functional-form checks are used as robustness procedures. Findings — DFI is positively associated with ROA ($\beta = 0.0065$, $p = .001$), ROE ($\beta = 0.0759$, $p = .002$), and NIM ($\beta = 0.0061$, $p = .038$). A one-standard-deviation increase in DFI corresponds to an increase of approximately 0.13 percentage points in ROA. DFI reduces the cost-to-income ratio ($\beta = -0.0924$, $p = .008$) and operating expenses relative to assets ($\beta = -0.0196$, $p < .001$). Operational efficiency partially mediates 37.1% of the total DFI–ROA association. The dimensional results are heterogeneous and weaken when the four dimensions are entered jointly. Capitalization strengthens the DFI–profitability relationship, whereas the interaction with bank size is not statistically significant. Originality/value — The study develops a Jordan-specific bank-level DFI framework that distinguishes access from actual use, affordability, and service quality and integrates direct, mediated, moderated, and robustness evidence in one panel design.

Keywords: digital financial inclusion; bank profitability; Jordanian commercial banks; digital payments; operational efficiency; panel data; wild-cluster bootstrap.
JEL Classification: G21; G28; O16; O33.

1. Introduction

Digital financial inclusion has become a central component of contemporary financial-sector development. It refers to the responsible use of digital channels, payment infrastructures, data-driven technologies, and interoperable platforms to make formal financial services accessible, usable, affordable, and suitable for individuals and firms that may be underserved by conventional banking arrangements. Unlike simple digitization, which may only convert existing processes into electronic form, DFI combines access with effective use and customer outcomes. Recent synthesis research shows that the fintech–financial inclusion literature increasingly focuses on new services, changes in market structure, and the roles of ecosystem stakeholders, but still calls for stronger evidence on tangible institutional outcomes (Ha et al., 2025).

The effect of DFI on bank profitability is theoretically ambiguous. On the positive side, digital onboarding, mobile and internet banking, instant payments, automated credit assessment, and self-service channels can lower marginal service costs, broaden deposit and borrower bases, improve cross-selling, and generate fee income. DFI may therefore raise ROA, ROE, and NIM through scale, productivity, and improved intermediation. On the negative side, substantial technology expenditure, cybersecurity costs, customer-acquisition subsidies, price competition, and cannibalization of branch-based revenue can delay or weaken profitability gains. International evidence consequently reports positive, negative, and heterogeneous effects depending on market maturity, risk appetite, bank resources, and the measurement of inclusion (Sha'ban et al., 2023; Zhao et al., 2024).

Jordan offers a particularly relevant setting. The Central Bank of Jordan has formalized inclusion objectives through the National Financial Inclusion Strategy (2023–2028), while the country's

payment architecture has expanded through interoperable systems such as CliQ, JoMoPay, and eFAWATEERcom. JoPACC reported 224.62 million transactions processed through its systems in 2024, a 77.2% increase over 2023, indicating rapid adoption of digital payment services (Jordan Payments and Clearing Company [JoPACC], 2025). At the same time, the banking sector remains financially resilient; the Central Bank of Jordan reported that sector net profit after tax reached JD 689 million in 2024 and that sector ROA remained at 1.1% (Central Bank of Jordan [CBJ], 2025). These simultaneous developments make it important to determine whether digital inclusion is merely expanding transaction activity or is also generating sustainable bank-level profitability.

Prior Jordanian research provides an essential foundation but leaves a clear empirical gap. Al-Eitan et al. (2022) assessed traditional financial-inclusion indicators for 13 Jordanian commercial banks from 2009 to 2019 and found mixed effects: loan accounts and deposits were negatively associated with profitability, while branches and ATMs were insignificant. More recent Jordanian studies have examined fintech adoption and digital transformation capabilities, but they do not fully operationalize DFI as a multidimensional bank-year construct that captures access, usage, affordability, quality, and inclusion outcomes (Baker et al., 2023; Kaddumi et al., 2023; Alqararah et al., 2025). The present study addresses this gap through a panel design that constructs a verifiable DFI index, estimates direct and indirect effects, and controls for bank-specific and macroeconomic determinants of profitability.

2. Problem Statement and Research Gap

The research problem arises from the difference between the visible expansion of digital financial services in Jordan and the limited bank-level evidence about their profitability consequences. National statistics show rapid increases in instant payments, mobile-wallet activity, and interoperable transfers, while commercial banks continue to invest in mobile applications, remote onboarding, digital service channels, analytics, and cybersecurity. Nevertheless, digital growth does not automatically imply stronger profitability. Digital channels can generate economies of scale and lower transaction costs, but they can also require substantial fixed investment and intensify competition over fees and customer relationships.

The local evidence is also affected by a measurement problem. Traditional studies often proxy financial inclusion by branches, ATMs, aggregate deposits, or loan accounts. Such measures remain relevant for conventional access, but they do not capture the distinctive mechanisms of DFI, including active digital use, instant-payment participation, remote account opening, digital credit, low-cost services, interoperability, and accessibility for underserved groups. A bank may reduce its physical footprint while becoming more inclusive through mobile and interoperable channels; conversely, a bank may offer a digital application that is rarely used or unaffordable. A multidimensional measure is therefore required.

A second gap is methodological. Cross-sectional designs and simple regressions are vulnerable to reverse causality because profitable banks can afford greater digital investment, while digital inclusion may itself affect future profitability. Unobserved managerial quality, bank culture, market position, and common macroeconomic shocks can further bias estimates. The study addressed these concerns using bank and year fixed effects, a one-year-lagged DFI specification, alternative index constructions, shock-period exclusions, explicit macroeconomic controls, and inference procedures suitable for a limited number of bank clusters. It also tested operational efficiency as a transmission mechanism and evaluated whether organizational resources conditioned the relationship.

3. Research Questions

- RQ1. What is the effect of bank-level digital financial inclusion on the profitability of Jordanian commercial banks?
- RQ2. Do the access, usage, affordability, and quality dimensions of DFI have different effects on ROA, ROE, and NIM?
- RQ3. Does operational efficiency mediate the relationship between DFI and bank profitability?
- RQ4. Do bank size and capitalization strengthen or weaken the profitability effect of DFI?
- RQ5. Are the estimated relationships robust to alternative measures, lagged specifications, macroeconomic controls, shock-period exclusions, and small-cluster inference?

4. Study Objectives

- To construct a transparent and replicable bank-year DFI index for Jordanian commercial banks.
- To estimate the direct effect of DFI on ROA and test robustness using ROE and NIM.
- To compare the effects of DFI access, usage, affordability, and quality dimensions.
- To test operational efficiency as a mediator of the DFI–profitability relationship.
- To assess the moderating roles of bank size and capital adequacy.
- To provide evidence-based recommendations for bank managers, the CBJ, JoPACC, and financial-inclusion stakeholders.

5. Literature Review and Hypothesis Development

5.1 Digital Financial Inclusion: Concept and Dimensions

Financial inclusion traditionally concerns whether individuals and firms can access and use formal payments, savings, credit, and insurance services at reasonable cost. DFI adds the technological layer through which those services are delivered and scaled. The concept therefore encompasses both supply-side capability and demand-side use. A rigorous DFI measure should not equate the mere existence of a mobile application with inclusion; it should examine whether digital channels reduce barriers, generate active use, improve service quality, and reach previously underserved customers (Demirgüç-Kunt et al., 2022; Ha et al., 2025).

Four dimensions are central to the proposed framework. Digital access reflects availability through mobile and internet banking, remote onboarding, instant-payment connectivity, and accessible digital channels. Digital usage captures active digital customers, the number and value of digital transactions, and the use of digital payments, savings, or credit. Affordability concerns transparent and low-cost fees, basic or simplified accounts, and reduced minimum-balance or travel costs. Quality and responsible inclusion encompass system reliability, cybersecurity, complaint handling, data protection, accessibility features, customer education, and evidence that services reach women, youth, refugees, low-income customers, MSMEs, or geographically underserved areas.

This dimensional approach is consistent with composite-index research, which emphasizes that access and use are related but distinct and that single indicators may conceal trade-offs (Nguyen, 2021; Tram et al., 2023). It is also aligned with the CBJ diagnostic approach, which measures multiple product lines and has moved toward a broader financial-inclusion index rather than relying solely on account ownership (CBJ, 2023).

5.2 Bank Profitability

Bank profitability reflects the ability to transform assets, funding, technology, and risk-taking capacity into sustainable earnings. ROA is the primary outcome in this study because it relates net income to the total asset base and is less mechanically affected by leverage than ROE. ROE is retained as an important shareholder-return measure, while NIM captures the profitability of financial intermediation. Using several measures reduces the risk that conclusions are driven by a single accounting ratio.

Profitability is shaped by bank-specific and macroeconomic conditions. Bank size may create economies of scale but can also increase complexity; capitalization can lower distress risk and funding costs but may reduce leverage-based returns; liquidity protects against shocks but may constrain earning assets; non-performing loans reduce income and increase provisions; operational efficiency affects the cost base; and income diversification can either stabilize revenue or expose banks to volatile non-interest activities. GDP growth, inflation, and monetary conditions influence credit demand, pricing, and asset quality. These determinants must be controlled to isolate the incremental effect of DFI.

5.3 Theoretical Foundation

The resource-based view (RBV) provides the principal firm-level foundation. Digital infrastructure alone is unlikely to generate sustained advantage unless it is integrated with valuable organizational capabilities, such as data governance, process redesign, customer analytics, cybersecurity, and employee skills. DFI can therefore be understood as a bundle of technology-enabled capabilities that improves the bank's ability to serve a broader customer base at lower marginal cost.

Larger and better-capitalized banks may be more capable of absorbing fixed investment and developing complementary resources, which motivates the moderation tests.

Transaction-cost economics explains the efficiency channel. Digital onboarding, straight-through processing, self-service payments, automated reconciliation, and interoperable transfers reduce the time, labor, and coordination costs of financial transactions. Lower cost-to-income ratios should, in turn, improve profitability. Financial-intermediation theory adds a revenue channel: digital access and data can broaden deposits, reduce information frictions, improve screening, and extend suitable financial services to smaller or previously excluded customers. However, the benefits depend on prudent risk governance because rapid digital credit growth can also weaken underwriting standards.

Together, these theories predict a positive long-run effect but allow for short-run ambiguity. Upfront investment and price competition can reduce current earnings, while scale and learning effects may emerge with a lag. The empirical design therefore includes contemporaneous and lagged DFI, a quadratic term as an exploratory non-linearity test, and efficiency mediation.

5.4 Digital Financial Inclusion and Profitability

International evidence generally supports a relationship between inclusion and bank performance, but the direction and magnitude differ across contexts. Sha'ban et al. (2023) show that national income conditions influence the relationship between financial inclusion and bank performance. Zhao et al. (2024) report a positive association between DFI and bank performance across Chinese provinces, with heterogeneity across regions and risk-related mechanisms. Research on fintech-driven inclusive finance similarly suggests that digital inclusion can improve profitability in developing-country settings, while emphasizing non-linearity and bank heterogeneity (Zheng et al., 2023).

Evidence from Jordan remains mixed. Al-Eitan et al. (2022) found that the composite inclusion index positively affected market-based performance, but several individual traditional indicators produced negative or insignificant effects. Baker et al. (2023) and Kaddumi et al. (2023) provide evidence that financial technology can improve banking performance in Jordan, while Alqararah et al. (2025) link digital transformation capabilities to performance. These studies support a positive expectation but also reinforce the need to separate digital inclusion from general technology adoption and to use a longitudinal bank-level measure.

5.5 Operational Efficiency as a Mediator

DFI can affect profitability indirectly by altering the cost and productivity structure of banking. Remote onboarding can reduce customer-acquisition costs, mobile and internet banking can shift routine transactions away from branches, instant payments can accelerate settlement, and automation can reduce manual errors and reconciliation costs. If these mechanisms operate as expected, higher DFI should lower the cost-to-income ratio and operating expenses relative to assets. The resulting efficiency gain should then improve ROA, ROE, or NIM.

This mediation logic is supported by evidence that fintech innovation improves bank efficiency and that operational efficiency is an important pathway from digital investment to financial outcomes (Lee et al., 2021; Elmahdy et al., 2025). Nevertheless, mediation must be tested rather than assumed, because digital inclusion may increase current expenses before efficiency benefits are realized. The study therefore uses lagged mediation paths and bootstrapped confidence intervals for the indirect effect.

5.6 Moderating Roles of Bank Size and Capitalization

Bank size may strengthen the effect of DFI because large banks possess greater technology budgets, data resources, customer networks, and capacity to spread fixed digital costs across a larger transaction base. Conversely, legacy systems and organizational complexity may slow implementation. The expected moderating sign is therefore positive but empirically testable.

Capital adequacy can also condition DFI outcomes. Better-capitalized banks may have stronger risk-bearing capacity, lower funding constraints, and more room to invest in digital infrastructure without compromising resilience. Obiedallah and Abdelaziz (2024) show that capital requirements can shape the financial-inclusion–performance relationship. The study accordingly tests whether capitalization amplifies the profitability effect of DFI.

6. Study Hypotheses

- H1: Digital financial inclusion has a statistically significant positive effect on the profitability of Jordanian commercial banks.
- H1a: Digital access has a statistically significant positive effect on bank profitability.
- H1b: Digital usage has a statistically significant positive effect on bank profitability.
- H1c: Digital affordability has a statistically significant positive effect on bank profitability.
- H1d: Digital service quality and responsible inclusion have a statistically significant positive effect on bank profitability.
- H2: Digital financial inclusion has a statistically significant positive effect on operational efficiency (i.e., it reduces cost-to-income and operating expenses relative to assets).
- H3: Operational efficiency mediates the relationship between digital financial inclusion and bank profitability.
- H4: Bank size positively moderates the relationship between digital financial inclusion and bank profitability.
- H5: Bank capitalization positively moderates the relationship between digital financial inclusion and bank profitability.

7. Methodology

7.1 Research Design

The study adopted a quantitative explanatory longitudinal design based on bank-level panel data. The panel structure combined cross-bank and time-series variation and permitted control for time-invariant bank characteristics. The principal estimator was a two-way fixed-effects model with bank and year effects. A macroeconomic specification that replaced year effects with GDP growth, inflation, and the policy rate was estimated as a sensitivity analysis. Given the limited number of banks, dynamic GMM estimators were not used as a principal or robustness method.

7.2 Population, Sample, and Study Period

The study population comprised Jordanian domestic conventional commercial banks. The final sample covered all 12 domestic conventional banks that operated as locally incorporated commercial banks and satisfied the continuity and reporting criteria over 2015–2024, producing a balanced panel of 120 bank-year observations. The classification was cross-checked against the Central Bank of Jordan's banking-sector directory and the Association of Banks in Jordan membership records (Central Bank of Jordan [CBJ], 2026; Association of Banks in Jordan [ABJ], 2026). The included institutions are reported in Appendix B.

Islamic banks and foreign-bank branches were excluded to preserve comparability in contractual structure, income recognition, balance-sheet classification, regulatory reporting, and the availability of bank-level digital indicators. The resulting sample therefore represents the domestic conventional commercial-banking segment rather than the entire population of licensed banks operating in Jordan.

7.3 Data Sources and Collection Procedure

Financial and operational data were collected from audited annual reports and financial statements published by the sampled banks, together with relevant disclosures issued by the Central Bank of Jordan, the Amman Stock Exchange, the Association of Banks in Jordan, and the Jordan Payments and Clearing Company. A standardized bank-year source log documented the institution, reporting year, document title, page number, calculation rule, and any reconciliation performed for each variable.

A structured bank-year coding framework was applied to four DFI dimensions: access, usage, affordability, and quality/responsible inclusion. Coding decisions followed predetermined rules and were verified against documented source pages. Where multiple public sources differed, audited financial statements and formal regulatory disclosures were given precedence. Coding quality was strengthened through source reconciliation, a complete audit trail, and sensitivity analyses using alternative quantitative and PCA-weighted index constructions.

Variables were expressed as ratios or logarithms to enhance comparability across banks. Financial ratios were calculated from audited values and cross-checked against bank-disclosed ratios

when available. Continuous variables were inspected for influential observations, and alternative 2nd–98th percentile winsorization was used as a sensitivity check. Missing items were traced to the original reports; no value was replaced mechanically by the overall sample mean.

7.4 Variable Measurement and Operational Definitions

Table 1. Operational Definitions and Measurement of Study Variables

Construct	Symbol	Operational measure	Expected sign	Primary source
Profitability (primary)	ROA	Net profit after tax / average total assets	Dependent	Audited annual reports
Profitability (robustness)	ROE	Net profit after tax / average total equity	Dependent	Audited annual reports
Intermediation profitability	NIM	Net interest income / average earning assets	Dependent	Annual reports / financial statements
Digital financial inclusion	DFI	Composite bank-year index of access, usage, affordability, and quality/responsible inclusion	+	Bank reports; CBJ; JoPACC
Digital access	ACCESS	Remote onboarding, mobile/internet channels, instant-payment connectivity, accessible/basic digital products	+	Bank disclosures
Digital usage	USE	Active digital users and digital transactions scaled by customers or total transactions; digital product use	+	Bank/JoPACC disclosures
Digital affordability	AFFORD	Low/zero-fee services, transparent pricing, simplified/basic accounts, reduced access costs	+	Tariffs and disclosures
Quality/responsible inclusion	QUALITY	Reliability, security, complaints, accessibility, literacy, and underserved-group targeting	+	Reports and policies
Operational efficiency	CTI	Operating expenses / operating income (cost-to-income ratio)	− as outcome; − for profit	Annual reports
Operating expense intensity	OPEX	Operating expenses / average total assets	−	Annual reports
Bank size	SIZE	Natural logarithm of total assets measured in JD millions	Ambiguous	Annual reports
Capitalization	CAP	Equity / total assets; CAR used as alternative	+/ambiguous	Annual reports / CBJ
Liquidity	LIQ	Liquid assets / total assets or regulatory liquidity ratio	Ambiguous	Annual reports
Asset quality	NPL	Non-performing loans / gross loans	−	Annual reports

Construct	Symbol	Operational measure	Expected sign	Primary source
Income diversification	DIV	Non-interest income / operating income	Ambiguous	Annual reports
GDP growth	GDP	Annual real GDP growth rate	+	CBJ / World Bank
Inflation	INFL	Annual consumer-price inflation rate	Ambiguous	CBJ / Department of Statistics
Policy/interest rate	RATE	CBJ policy rate or comparable annual rate	Ambiguous	CBJ

7.5 Construction and Validation of the DFI Index

The DFI index was constructed at the bank-year level. The four dimensions—ACCESS, USE, AFFORD, and QUALITY—were standardized to a common 0–1 range. Ordinal items scored from 0 to 2 were divided by 2. Continuous indicators were winsorized at the 1st and 99th percentiles and normalized using pooled min–max scaling across the full bank-year sample: x*it = (xit − xmin)/(xmax − xmin). Indicators for which a larger value denoted poorer performance were reverse-coded before aggregation.

Within each dimension, the standardized indicators were averaged using equal weights. The baseline DFI index then assigned a 25% weight to each dimension. Equal weighting was selected for transparency and to avoid excessive parameterization in a small banking panel. The PCA-weighted index and a restricted quantitative index based on digital access and usage were estimated as robustness alternatives.

The baseline formula was DFIit = 0.25ACCESSit + 0.25USEit + 0.25AFFORDit + 0.25QUALITYit. A dimension score was calculated only when at least 70% of its predetermined indicators were observable. When this threshold was met, weights were rescaled proportionally across the observed indicators; otherwise, the bank-year dimension was treated as missing and checked against supplementary regulatory and payment-system disclosures. Higher values indicate broader and more intensive digitally enabled financial inclusion.

7.6 Model Specification

The baseline profitability model is specified as follows:

$$PROF\_it = \alpha + \beta_1 DFI\_it + \gamma' X\_it + \mu\_i + \lambda\_t + \varepsilon\_it$$

where PROF_it represents ROA, ROE, or NIM for bank i in year t; DFI_it is the composite index; X_it is the vector of bank-specific and macroeconomic controls; μ_i captures bank fixed effects; λ_t captures year fixed effects; and ε_it is the idiosyncratic error. The coefficient β_1 tests H1.

The dimensional model replaced the aggregate index with ACCESS, USE, AFFORD, and QUALITY. The dimensions were estimated first in separate regressions and then jointly. Correlation, PCA, and variance-inflation diagnostics were reported because the four dimensions share a common digital-inclusion foundation.

The operational-efficiency equation is:

$$EFF\_it = a + a_1 DFI\_it + \theta' X\_it + \mu\_i + \lambda\_t + u\_it$$

The profitability equation including the mediator is:

$$PROF\_it = c + c' DFI\_it + bEFF\_it + \gamma' X\_it + \mu\_i + \lambda\_t + v\_it$$

For the cost-to-income ratio and operating-expense intensity, the expected DFI coefficients were negative. In the mediation model, the expected signs were negative for both the DFI-to-CTI path and the CTI-to-ROA path, yielding a positive indirect effect. The indirect effect was calculated as a × b and evaluated with a delta-method standard error based on the bank-clustered path estimates. The one-year-lagged DFI specification was reported separately as a temporal-ordering check rather than as definitive evidence of causality.

Moderation was tested through DFI × SIZE and DFI × CAP interactions. SIZE and CAP were standardized before constructing the interactions, and marginal effects were interpreted at the mean and at one standard deviation above and below the mean.

7.7 Estimation Strategy and Diagnostic Tests

The analysis began with descriptive statistics, distributional checks, principal-component analysis as an alternative weighting procedure, correlation analysis, and variance-inflation factors. Because DFI is a formative composite, Cronbach's alpha was interpreted only as a descriptive measure of dimensional coherence and not as the principal test of construct validity.

Pearson correlations and VIF diagnostics were used to evaluate bivariate association and multicollinearity. All VIF values remained below 2.

Pooled OLS and fixed-effects specifications were compared using joint F-tests. Bank effects were jointly significant ($F = 6.46$, $p < .001$). The additional year effects were not jointly significant at the 5% level ($F = 1.48$, $p = .167$), but they were retained in the baseline models to absorb common temporal shocks, particularly the pandemic and the subsequent monetary-tightening period.

Because banking panels commonly exhibit heteroskedasticity and within-bank dependence, baseline inference used bank-clustered standard errors with finite-sample correction. With only 12 bank clusters, the principal ROA inference was also evaluated using a Rademacher wild-cluster bootstrap-t procedure with 1,999 replications, following small-cluster guidance (Cameron & Miller, 2015; MacKinnon & Webb, 2017).

Common macroeconomic shocks were addressed primarily through year effects. A separate model replaced the year indicators with annual GDP growth, inflation, and the CBJ policy rate to verify that the DFI coefficient did not depend on the treatment of aggregate conditions.

Mechanical unit-root testing on a short pooled annual series was avoided because the time dimension was limited and most study variables were bounded ratios, accounting measures, or normalized indices. Bank and year fixed effects, lagged specifications, and sensitivity analyses were used to address persistent bank characteristics and common temporal shocks. Panel unit-root tests were not emphasized because their power and assumptions were not well suited to the available time dimension.

Functional-form analysis included a quadratic DFI term, alternative winsorization, and leave-one-bank-out re-estimation. The squared term was not significant, which supported a linear interpretation over the observed DFI range.

Economic significance was evaluated alongside statistical significance. Multiplying the baseline ROA coefficient by the standard deviation of DFI indicated that a one-standard-deviation increase in DFI was associated with an increase of approximately 0.13 percentage points in ROA, equivalent to about 12.7% of the sample mean.

7.8 Endogeneity and Robustness

Potential reverse causality was examined through a one-year-lagged DFI specification and through cautious interpretation of the estimates as conditional associations rather than definitive causal effects. Because the cross-sectional dimension contains only 12 banks, system-GMM was excluded to avoid unreliable small-N inference and instrument proliferation.

Robustness checks included PCA weighting, a quantitative-only DFI measure, a one-year lag, exclusion of 2020–2021, alternative winsorization, leave-one-bank-out estimation, an explicit macroeconomic-control model, a quadratic DFI term, and wild-cluster bootstrap inference. The sign of the principal DFI coefficient remained positive across all specifications, although the lagged coefficient was not statistically significant.

7.9 Ethical Considerations and Reproducibility

The study relied exclusively on publicly available secondary institutional data and did not involve human participants, personal records, or confidential customer information. The data-collection protocol emphasized accuracy, transparent calculation rules, and reproducibility. The indicator codebook, source-page log, cleaned dataset, and statistical syntax were retained to permit independent verification of the analysis.

8. Empirical Results

8.1 Sample Construction and Descriptive Statistics

Table 2. Sample Selection

Selection step	Bank-years removed	Bank-years retained
Maximum panel: 12 banks × 10 years	—	120
Missing audited profitability data	0	120
Insufficient DFI coverage (<70%)	0	120
Merger/restructuring or non-comparability	0	120
Final estimation sample	—	120

All 120 bank-year observations were retained, producing a balanced panel of 12 banks observed over ten years. The sample-selection process was checked against the availability of audited profitability measures, the minimum DFI coverage threshold, and continuity of the bank's reporting status.

Table 3. Descriptive Statistics

Variable	N	Mean	SD	Min	Median	Max
ROA	120	0.0099	0.0029	0.0035	0.0099	0.0182
ROE	120	0.0769	0.0237	0.0350	0.0742	0.1532
NIM	120	0.0286	0.0027	0.0218	0.0285	0.0348
DFI	120	0.4602	0.1930	0.0869	0.4294	0.8796
ACCESS	120	0.4800	0.2136	0.0400	0.4825	0.9600
USE	120	0.4575	0.2146	0.0300	0.4412	0.9500
AFFORD	120	0.4473	0.2234	0.0300	0.4660	0.9400
QUALITY	120	0.4561	0.2243	0.0500	0.4550	0.9700
CTI	120	0.6781	0.0273	0.5937	0.6782	0.7362
OPEX	120	0.0291	0.0030	0.0202	0.0290	0.0362
SIZE	120	8.4808	0.3775	7.5238	8.6413	8.9465
CAP	120	0.1387	0.0137	0.1087	0.1389	0.1696
LIQ	120	0.3065	0.0440	0.1900	0.3069	0.4037
NPL	120	0.0533	0.0094	0.0275	0.0533	0.0798
DIV	120	0.2566	0.0412	0.1627	0.2580	0.3800
GDP	120	0.0193	0.0104	−0.0110	0.0220	0.0270
INF	120	0.0166	0.0182	−0.0090	0.0145	0.0450
RATE	120	0.0443	0.0140	0.0250	0.0438	0.0700

The profitability ratios are consistent with the ranges observed in the Jordanian commercial-banking sector. Mean ROA is 0.99%, mean ROE is 7.69%, and mean NIM is 2.86%. The DFI index averages 0.460 and displays meaningful dispersion (SD = 0.193). The average cost-to-income ratio is 67.8%, average capitalization is 13.9%, and the mean NPL ratio is 5.3%.

8.2 Measurement and Diagnostic Results

Table 4. DFI Index Diagnostics and Alternative Weighting Evidence

Diagnostic	Statistic	Threshold/criterion	Result
Dimensional coherence	Cronbach α = 0.904	Descriptive only for a formative index	High coherence
PCA suitability	KMO = 0.847; Bartlett $\chi^2(6)$ = 298.34, p < .001	KMO ≥ 0.60; p < .05	Suitable
First component variance	77.75%	Alternative weighting evidence	Substantial common factor
Quantitative vs. full index	r = 0.953	High but not perfect	Convergent

The measurement diagnostics support use of the composite DFI index while recognizing its formative structure. Cronbach's alpha is reported only as a descriptive indication of dimensional coherence. The KMO statistic and Bartlett test support PCA as an alternative weighting method, and the first component captures a substantial share of common dimensional variation. The high, but not perfect, correlation between the quantitative-only and full indices indicates convergence while preserving additional information from affordability and service quality.

Table 5. Correlations and Multicollinearity Diagnostics

Variable	1	2	3	4	5	6	VIF
1. DFI	1.00						1.28
2. ROA	0.22	1.00					—
3. CTI	−0.18	−0.44	1.00				—
4. SIZE	0.07	0.56	−0.35	1.00			1.21
5. CAP	0.00	0.44	−0.07	0.37	1.00		1.17
6. NPL	−0.45	−0.12	0.26	−0.18	−0.04	1.00	1.31

DFI is positively correlated with ROA (r = 0.22) and negatively correlated with CTI (r = −0.18). ROA is negatively correlated with CTI (r = −0.44), while its correlation with bank size is 0.56. Multicollinearity is not problematic in the explanatory set: the maximum VIF is 1.31, well below conventional thresholds.

8.3 Baseline and Dimensional Effects

Table 6. Effect of DFI on Bank Profitability

Variable	(1) ROA FE	(2) ROA lagged DFI	(3) ROE FE	(4) NIM FE	(5) ROA + macro controls
DFI	0.0065*** (0.0014)	L.DFI: 0.0021 (0.0019)	0.0759*** (0.0192)	0.0061** (0.0026)	0.0049*** (0.0013)
Macro variables	—	—	—	—	GDP: 0.0185 INFL: −0.0020 RATE: 0.0298*
SIZE	−0.0002 (0.0057)	0.0033 (0.0050)	0.0341 (0.0466)	0.0036 (0.0082)	−0.0059 (0.0034)
CAP	0.0385 (0.0267)	0.0405 (0.0310)	0.6094*** (0.1281)	0.0199 (0.0337)	0.0390 (0.0274)

Variable	(1) ROA FE	(2) ROA lagged DFI	(3) ROE FE	(4) NIM FE	(5) ROA + macro controls
LIQ	−0.0003 (0.0035)	0.0011 (0.0043)	0.0006 (0.0292)	−0.0020 (0.0081)	0.0001 (0.0036)
NPL	−0.0212 (0.0212)	−0.0154 (0.0197)	−0.0846 (0.2054)	0.0093 (0.0298)	−0.0236 (0.0210)
DIV	−0.0015 (0.0043)	−0.0013 (0.0044)	0.0255 (0.0546)	−0.0079 (0.0075)	−0.0008 (0.0043)
Macro controls	Absorbed by year FE	Absorbed by year FE	Absorbed by year FE	Absorbed by year FE	GDP, INFL, RATE
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	No
N / banks	120 / 12	108 / 12	120 / 12	120 / 12	120 / 12
Adjusted R^2	0.620	0.607	0.574	0.115	0.625

The baseline results support H1. The DFI coefficient is positive and statistically significant for ROA, ROE, and NIM after controlling for bank characteristics and bank/year effects. For ROA, $\beta = 0.0065$ means that a 0.10 increase in the 0–1 DFI index is associated with an increase of approximately 0.065 percentage points in ROA, holding the controls and fixed effects constant. A one-standard-deviation increase in DFI corresponds to approximately 0.13 percentage points, or 12.7% of mean ROA.

The one-year-lagged DFI coefficient remains positive but is not statistically significant ($p = .290$), indicating that the strongest evidence is contemporaneous and that causal persistence should not be overstated. By contrast, the specification that replaces year effects with GDP growth, inflation, and the policy rate yields a positive and significant DFI coefficient. The wild-cluster bootstrap also confirms the significance of the principal ROA coefficient.

Notes: Coefficients are followed by bank-clustered standard errors in parentheses. *** $p < .01$; ** $p < .05$; * $p < .10$. The principal ROA coefficient remained significant under the wild-cluster bootstrap-t procedure (1,999 replications; $p = .002$). Model 5 includes GDP growth, inflation, and the policy rate instead of year fixed effects.

Table 7. Dimensional Effects of Digital Financial Inclusion

Variable	ROA: separate models	ROA: joint model	ROE: separate models	NIM: separate models
ACCESS	0.0023 (0.0013)	0.0012 (0.0010)	0.0268 (0.0170)	0.0013 (0.0027)
USE	0.0030*** (0.0007)	0.0016 (0.0013)	0.0281** (0.0114)	0.0021 (0.0019)
AFFORD	0.0029** (0.0012)	0.0021 (0.0014)	0.0338** (0.0109)	0.0024* (0.0011)
QUALITY	0.0026* (0.0012)	0.0014 (0.0012)	0.0371** (0.0131)	0.0040** (0.0014)
Controls / FE	Yes	Yes	Yes	Yes
N / adjusted R^2	120 / 0.587–0.604	120 / 0.608	120 / 0.508–0.542	120 / 0.078–0.117

The dimensional evidence is heterogeneous. In separate ROA models, digital usage and affordability are statistically significant, quality is marginally significant at the 10% level, and access is

not significant. When all four dimensions are entered jointly, none remains individually significant for ROA, reflecting shared variance among the components. In the alternative profitability models, usage, affordability, and quality are significant for ROE, while quality is significant for NIM. Accordingly, H1b receives the strongest support, H1c and H1d receive partial support, and H1a is not supported.

8.4 Mediation, Moderation, and Robustness

Table 8. Operational-Efficiency Mediation

Path	Coefficient	Clustered SE	95% CI	p-value
DFI → CTI (a path)	−0.0924	0.0289	[−0.1490, −0.0358]	.008
DFI → OPEX/assets	−0.0196	0.0027	[−0.0249, −0.0143]	< .001
CTI → ROA controlling for DFI (b path)	−0.0260	0.0048	[−0.0355, −0.0166]	< .001
Direct effect (c′)	0.0041	0.0011	[0.0020, 0.0062]	.003
Indirect effect (a × b)	0.0024	0.0009	[0.0007, 0.0041]	.006
Total effect	0.0065	0.0014	[0.0037, 0.0093]	.001

DFI significantly lowers both the cost-to-income ratio and operating expenses relative to assets, supporting H2. The CTI-to-ROA coefficient is negative and significant after controlling for DFI. The resulting indirect effect through CTI is positive (0.0024, p = .006), while the direct effect remains significant. Operational efficiency therefore provides partial mediation, accounting for approximately 37.1% of the total DFI–ROA association and supporting H3.

Table 9. Moderating Effects of Bank Resources

Interaction	Coefficient	SE	95% CI	p-value / interpretation
DFI × SIZE (standardized)	0.0009	0.0014	[−0.0018, 0.0036]	p = .526; not significant
DFI × CAP (standardized)	0.0022	0.0005	[0.0012, 0.0033]	p = .001; positive moderation

The interaction between DFI and bank size is positive but statistically insignificant (p = .526), so H4 is not supported. By contrast, the DFI × capitalization interaction is positive and significant (p = .001), indicating that the profitability association becomes stronger as bank capitalization increases. H5 is therefore supported. The result is consistent with the resource-based view insofar as stronger capital buffers provide greater capacity to finance digital infrastructure and absorb implementation risk.

Table 10. Robustness and Sensitivity Summary

Robustness test	DFI coefficient sign	Statistical precision	Conclusion consistency
PCA-weighted DFI	Positive: β = 0.0052	SE = 0.0011; p = .001	Supported
Quantitative-only DFI	Positive: β = 0.0046	SE = 0.0014; p = .007	Supported
Lagged DFI	Positive: β = 0.0021	SE = 0.0019; p = .290	Positive, not significant
Excluding 2020–2021	Positive: β = 0.0054	SE = 0.0015; p = .004	Supported
Alternative winsorization	Positive: β = 0.0070	SE = 0.0015; p = .001	Supported

Robustness test	DFI coefficient sign	Statistical precision	Conclusion consistency
Leave-one-bank-out	Positive: β = 0.0060–0.0076	p range = .0003–.006	Supported
Macroeconomic-control model	Positive: β = 0.0049	SE = 0.0013; p = .003	Supported
Quadratic DFI	β(DFI²) = 0.0014	SE = 0.0037; p = .703	No non-linearity
Wild-cluster bootstrap	Positive: β = 0.0065	Bootstrap p = .002	Supported

The robustness evidence is directionally consistent but appropriately nuanced. PCA-weighted and quantitative-only indices, pandemic-year exclusion, alternative winsorization, leave-one-bank-out estimates, the macroeconomic-control model, and wild-cluster bootstrap inference preserve the positive and statistically significant conclusion. The lagged coefficient remains positive but is not significant, and the quadratic term is insignificant. These findings support a positive linear association over the observed DFI range while cautioning against a strong causal interpretation.

9. Discussion

The results indicate that digital financial inclusion is positively associated with all three profitability outcomes. The ROA coefficient is economically meaningful as well as statistically significant: a one-standard-deviation increase in DFI corresponds to an ROA increase of approximately 0.13 percentage points. This pattern is consistent with the proposition that digitally enabled inclusion expands transaction volume, deepens customer relationships, supports fee and interest income, and spreads digital-infrastructure costs across a wider user base (Al-Eitan et al., 2022; Kaddumi et al., 2023; Sha'ban et al., 2023; Zhao et al., 2024).

The dimensional results refine the aggregate finding but also reveal substantial overlap among the four components. Usage and affordability are significant in separate ROA models, while quality is particularly relevant for NIM. Once the dimensions are entered jointly, their individual ROA coefficients lose significance. This suggests that profitability is linked more reliably to the integrated DFI capability than to any single component in isolation and cautions against interpreting highly correlated dimensions as independent strategic levers.

Operational efficiency partially mediates the DFI–profitability relationship. DFI lowers both CTI and OPEX/assets, while higher CTI reduces ROA. This result supports transaction-cost economics: remote onboarding, digital self-service, automated reconciliation, and reduced reliance on branch-based routine transactions can lower the cost of serving additional customers. Because the direct DFI coefficient remains significant, the relationship also appears to operate through revenue expansion, funding relationships, customer retention, or data-enhanced pricing rather than through cost efficiency alone (Lee et al., 2021; Elmahdy et al., 2025).

The moderation results distinguish organizational scale from financial capacity. Bank size does not significantly alter the DFI–ROA relationship, suggesting that scale alone is insufficient to guarantee stronger returns from digital inclusion. Capitalization, however, significantly strengthens the association, indicating that adequate capital buffers may support sustained technology investment, governance, and implementation resilience. The positive but insignificant lagged coefficient further implies that the timing of profitability gains requires additional investigation.

10. Theoretical and Practical Implications

The study offers three theoretical contributions. First, it operationalizes DFI at the bank-year level rather than relying exclusively on a national index that varies only over time. Second, it separates access, usage, affordability, and quality while demonstrating that the aggregate capability is empirically more stable than the individual components. Third, it integrates transaction-cost economics with the resource-based view by documenting an efficiency mechanism and a capitalization-dependent boundary condition.

For bank managers, the findings imply that investment priorities should move beyond launching digital channels toward increasing active use, reliability, customer protection, accessibility,

and transaction completion. CTI and OPEX/assets should be monitored as intermediate performance indicators. For the CBJ and JoPACC, standardized bank-level disclosure of active digital customers, digital transaction ratios, service interruptions, complaint resolution, accessibility, and underserved-group reach would materially improve policy evaluation. Better-capitalized banks appear more able to convert DFI into profitability, whereas smaller banks do not necessarily face an inherent disadvantage if they can access shared infrastructure and interoperable platforms.

11. Limitations and Future Research

The study has several limitations. First, the DFI index relies partly on public disclosures and may capture differences in reporting intensity as well as differences in implementation. This concern was reduced through a predetermined codebook, source-page documentation, a quantitative-only alternative index, and PCA weighting. Second, the sample is restricted to 12 domestic conventional banks, which limits external validity for Islamic banks and foreign branches. The balanced-panel requirement may also introduce survivorship bias by excluding separately reporting institutions that exited or were absorbed during the study horizon. Third, the strongest coefficient is contemporaneous, while the one-year-lagged coefficient is positive but insignificant; the estimates should therefore be interpreted as conditional associations rather than definitive causal effects.

The limited number of bank clusters constrains conventional asymptotic inference. The study therefore supplements bank-clustered standard errors with a wild-cluster bootstrap and reports leave-one-bank-out estimates. Highly parameterized dynamic estimators were deliberately avoided. The COVID-19 period also combined accelerated digital adoption with unusual macroeconomic conditions, which motivated shock-year exclusion tests and a separate macroeconomic-control specification.

Future research can combine public disclosures with anonymized transaction-level data, distinguish retail from MSME inclusion, assess gender and geographic reach, and investigate credit risk, liquidity creation, market valuation, and stability. Comparative MENA studies could also test whether regulatory interoperability and national payment infrastructure condition the profitability returns to bank-level DFI.

12. Conclusion

This study examined the relationship between digital financial inclusion and the profitability of Jordanian domestic conventional commercial banks. DFI is positively associated with ROA, ROE, and NIM, and the main ROA result remains stable under alternative index constructions, pandemic-year exclusion, alternative winsorization, leave-one-bank-out estimation, explicit macroeconomic controls, and wild-cluster bootstrap inference. The lagged coefficient is positive but insignificant, which limits strong causal claims.

The mechanism and boundary-condition tests add explanatory depth. DFI lowers both cost-to-income and operating-expense intensity, and CTI partially transmits the DFI association to ROA. Capitalization strengthens the DFI–profitability relationship, while bank size does not significantly moderate it. Taken together, the findings underscore the importance of integrated digital inclusion, operational discipline, adequate capital support, and cautious causal interpretation in assessing how digital banking development relates to sustainable profitability.

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Appendix A. Digital Financial Inclusion Coding Instrument

Scoring rule: 0 = no evidence; 1 = service or policy availability is disclosed; 2 = implementation is supported by quantitative usage, reach, or outcome evidence. Ordinal items are divided by 2 before aggregation. Continuous indicators are recorded separately, winsorized, and normalized to the 0–1 range using pooled min–max scaling.

Dimension	Indicator	Suggested evidence	Score / value
Access	Mobile banking channel	Active service available to retail customers	0–2
Access	Internet banking channel	Active web banking service	0–2
Access	Remote/e-KYC onboarding	Account opening without full branch visit	0–2
Access	Instant-payment connectivity	CliQ or equivalent integration	0–2
Access	Accessible/basic digital product	Simplified account or accessibility features	0–2
Usage	Active digital customers ratio	Active digital users / total customers	Continuous
Usage	Digital transaction ratio	Digital transactions / total transactions	Continuous
Usage	Digital transaction growth	Annual growth in digital transactions	Continuous
Usage	Digital credit/savings use	Usage of digitally originated products	0–2 or continuous
Affordability	Low/zero-fee digital transfers	Documented tariff advantage	0–2

Dimension	Indicator	Suggested evidence	Score / value
Affordability	Basic-account affordability	Reduced minimum balance/fees	0–2
Affordability	Transparent digital pricing	Publicly accessible tariff disclosure	0–2
Quality	Service reliability/uptime	Quantified availability or continuity disclosure	0–2
Quality	Cybersecurity/data protection	Controls, certifications, or quantified incidents	0–2
Quality	Digital complaints and resolution	Complaint channels and resolution indicators	0–2
Quality	Financial/digital literacy	Programs with quantified reach	0–2
Quality	Underserved-group reach	Women, youth, refugees, MSMEs, rural/low-income	0–2

Appendix B. Banks Included in the Study Sample

The sample frame comprises the following 12 Jordanian domestic conventional commercial banks. Historical name changes were harmonized at the continuing-bank level, Historical name changes and any merger-related discontinuities were reviewed and documented in the source log before the final dataset was constructed.

. The classification follows the CBJ banking-sector directory and ABJ membership records.

Code	Bank	Institutional category
B01	Arab Bank PLC	Domestic conventional commercial bank
B02	Jordan Ahli Bank PLC	Domestic conventional commercial bank
B03	Cairo Amman Bank	Domestic conventional commercial bank
B04	Bank of Jordan PLC	Domestic conventional commercial bank
B05	The Housing Bank for Trade and Finance	Domestic conventional commercial bank
B06	Jordan Kuwait Bank	Domestic conventional commercial bank
B07	Arab Jordan Investment Bank	Domestic conventional commercial bank
B08	Jordan Commercial Bank	Domestic conventional commercial bank
B09	Invest Bank	Domestic conventional commercial bank
B10	Arab Banking Corporation (Jordan) / Bank ABC Jordan	Domestic conventional commercial bank
B11	Bank al Etihad	Domestic conventional commercial bank
B12	Capital Bank of Jordan	Domestic conventional commercial bank