

DIGITALISATION AND BANKING PERFORMANCE IN NIGERIA: A TWO-DECADE ANALYSIS OF PROFITABILITY AND EFFICIENCY MECHANISMS

Gilbert Deinde IFARAJIMI<sup>1</sup> and Abayomi Oluwaseun JAPINYE<sup>2\*</sup>

<sup>1</sup>Department of Economics, Caleb University, Lagos, Nigeria

<sup>2</sup>Compliance Department, Central Bank of Nigeria

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**Abstract:** This paper employs a panel data analysis of 20 years (2005-2024) of six listed banks in Nigeria to examine the relationship between bank digitalisation and financial performance. The composite digitalisation index is built from seven indicators at the bank level covering ICT spending, delivery infrastructure, and transaction activity, and two-way fixed-effects models are estimated to account for bank-specific and macroeconomic heterogeneity. Once these are controlled for, digitalisation is not significantly associated with profitability (ROA or ROE). In contrast, digital growth is also accompanied by increases in operating expenses, as measured by the cost-to-income ratio, which is in line with the front-loaded investment and scaling costs. Exploratory threshold analysis suggests that effects could be different at different levels of digital intensity, but there is little evidence of nonlinearities. The findings show that digitalisation in the Nigerian banking sector is a long-term strategic commitment with relatively little and delayed profitability implications in the short run. The paper is a valuable addition to the digital finance literature as it offers long run bank-level evidence from an emerging African economy and highlights the importance of cost dynamics and investment timing in the assessment of the outcomes of digital transformation.

**Keywords:** Bank digitalisation, Emerging markets, Financial performance, Nigerian banking, Operational efficiency, Panel data

**JEL Classification:** C23, G21, L86, O3

## 1. Introduction

The Nigeria banking industry is not the same as it was in 2005. ATM networks, POS infrastructure, mobile and internet banking platforms have all expanded sharply over the past two decades, driven in large part by regulatory pressure to broaden financial access and, more recently, by fintech competition that incumbent banks could not afford to ignore (Central Bank of Nigeria, 2024; Asongu and Odhiambo, 2023). This change is not so clear-cut in terms of the improvement of bank performance. Digital channels offer reduced costs and greater reach, but at a high initial expense and with cyber and operational risk that branch banking does not carry. The net outcome can't be solved by theory.

There has been a significant increase in scholarship globally on bank digitalisation, but the African context is lacking. Most studies rely on a short observation window or a limited number of observations, which limits the ability to infer from a longer time series (Citterio et al., 2024; Xu et al., 2025). Despite the growing evidence that digitalisation is a multi-dimensional phenomenon, involving investment, infrastructure, and usage intensity, single-dimension digital proxies, such as ATM density or binary adoption flags, are still widely used. The efficiency channel has been less researched than the other channels, and how digital technologies contribute to profitability through this channel has been explored in particular limited ways (Zhang et al., 2024). The existing studies available for Nigerian banks are limited in scope and sample size and are based on information that is too old to reflect the latest wave of digital acceleration that has taken place since 2020 (Central Bank of Nigeria, 2024; NDIC, 2023). The results from previous studies are also conflicting; some show positive relationships between digital

transformation and profitability (Citterio et al., 2024; Liu et al., 2023), while others indicate nonlinear, heterogeneous or non-significant relationships that seem to be sensitive to bank characteristics, digital intensity and market conditions (Ayadi et al., 2024; Zhang et al., 2024).

This study attempts to fill this lacuna by examining a two decade panel of six listed Nigerian banks. The seven bank-level indicators are combined to form a composite digitalisation index and two-way fixed-effects models are estimated. The inquiry is guided by the following questions:

1. What is the effect of bank digitalisation on the return on assets and return on equity of Nigerian listed commercial banks?
2. To what extent does bank digitalisation influence operational efficiency as measured by the cost-to-income ratio?
3. How does the cost-to-income ratio mediate the relationship between bank digitalisation and profitability?
4. At what threshold of digital intensity, if any, does the effect of digitalisation on bank profitability change in direction or magnitude?

The study contributes long-run bank-level evidence from an emerging African economy, a multidimensional digitalisation index that overcomes single-proxy limitations, and explicit analysis of cost dynamics that are often overlooked in digital banking research. The remainder of the paper proceeds as follows: Section 2 reviews the literature and derives testable hypotheses; Section 3 describes the data and methodology; Section 4 reports empirical results; and Section 5 concludes.

## 2. Literature Review

The theoretical case for a relationship between digitalisation and bank performance is based on several traditions, each of which focuses on a different aspect of the relationship. The most relevant is the new growth theory. Arrow (1962) proposed that investment creates knowledge as an ancillary product that builds up and increases productivity separately from the investment. This is important for banks: the data from digital transaction platforms feeds into the productivity cycle, which in turn enhances credit scoring, fraud detection, and product design, and can be compounded over time. Romer (1986) expanded this to include the non-rival and increasing returns properties of knowledge: a bank's credit risk model doesn't wear out and the analytical capital in a digital system – the human capital acquired from working with such systems (Lucas, 1988) – yields returns that increase with transaction volume. These insights collectively imply that the payoff of digitalisation is not immediate, but accumulates over time, following a learning curve, and this is already implicit in the literature on empirical studies of efficiency. The resource-based view (RBV) proposed by Barney (1991) introduces a firm-level perspective: Digital capabilities (technological infrastructure, analytical competences, and the routines of the organisation to effectively adopt and use technology) are hard to imitate and hence can create sustainable competitive advantage if they are embedded (Wade and Hulland, 2004; Bharadwaj, 2000). According to the technology diffusion theory, adoption will follow the S-curve shape, with early adopters benefiting from first mover advantages and laggards being subjected to competitive pressure, suggesting that the performance implications are likely to vary across digital intensity levels and not be uniform (Rogers, 2003).

Digitalisation of the bank is not a single entity. At least three dimensions of measurement have been identified in the literature: investment measures, which measure ICT expenditure and technology-related operating costs as proxies of digital intensity (Berger, 2003; Furst et al., 2002); infrastructure measures, which measure the physical channel accessibility, such as ATM density and network breadth (Malhotra and Singh, 2009; Hasan et al., 2012); and utilisation measures, which measure actual adoption, including transaction volumes, number of active users, and digital revenue shares (Ciciretti et al., 2009). Indices that combine the three dimensions have higher construct validity but have not been widely used in emerging markets settings (Asongu and Odhiambo, 2023). The studies that use only one proxy can only measure one aspect of a multidimensional phenomenon, and that can account for some of the conflicting results found in the literature.

The theoretical case for an efficiency channel is very simple. Digital channels lower the cost of transactions by eliminating manual processes and the need for costly branch facilities. It has been estimated that the cost of services per transaction will be reduced by 50 to 70 per cent if the services are provided digitally instead of by tellers (Hernando and Nieto, 2007; Onay and Ozsoz, 2013). Self-service technologies decrease the number of employees needed; data analytics enhance the credit screening and risk management processes (Malhotra and Singh, 2009). The cost-to-income ratio is the main empirical instrument that can be used to monitor these dynamics. It is hoped that digital technologies will lower it on two paths: firstly by reducing operating costs (the numerator effect) and secondly, by increasing revenues as digital coverage expands and new fee income (Furst et al., 2002; Ciciretti et al., 2009) is generated (the denominator effect).

There is no clear-cut answer from the evidence. In early U.S. research, higher profitability was found to be linked to improved cost control and market penetration, due to cost savings and increased fees and deposits (Furst et al., 2002); DeYoung et al. (2007) found that advanced internet banking was associated with higher return on equity, as a result of fee income and deposit growth. European findings are more nuanced: Hernando and Nieto (2007) identified a negative long-term profitability effect after internet banking investments in Spanish banks, which seemed to be recovered after 3-4 years; and Ciciretti et al. (2009) detected a positive long-term efficiency effect, but not profitability, in Italian banks' internet banking investments. More recently, Citterio et al. (2024) reported positive digitalisation-profitability relationships for a European sample, and Ayadi et al. (2024) showed relationships that differed significantly depending on the characteristics of the banks and their level of digitalisation. In the Chinese context, the studies of Liu et al. (2023) and Zhang et al. (2024) also reveal a degree of heterogeneity, with both concluding that there are performance differences across bank size, ownership structure, and the extent of adoption.

There is little evidence in Africa. The results are generally similar to those obtained by Malhotra and Singh (2009) who were able to establish a positive relationship between technology intensity and profitability of Indian banks, but sensitive to the proxy used and the time of observation. Hasan et al. (2012) reported that the ATM expansion did not generate additional profits for Chinese banks, but did increase efficiency, a result that aligns with cost absorption when banks go digital. The regulatory process is as important as the empirical record for Nigeria. The CBN cashless policy, which was introduced in 2012, required electronic payment channels for high value transactions and facilitated the rapid growth of ATM and POS growth in the industry, with the post-2020 period seeing a further surge in growth due to the changes in customer behaviour during the pandemic (Central Bank of Nigeria, 2024). Research conducted before these stages cannot reflect the complete performance aspects of this cycle of transformation. The overall finding is that context determines outcomes: initial digitalisation tends to reduce profitability before improvements in efficiency become apparent (Hernando and Nieto, 2007); and the rate at which improvements in efficiency occur depends on market structure, infrastructure quality and customer uptake (Berger, 2003; Lechman and Popowska, 2022; Onay and Ozsoz, 2013).

These theories are not the only ones that exist, however, and an alternative theory exists which actually predicts the null result of no profits. DiMaggio and Powell (1983) draw attention to non-economic factors that influence organisational behaviour in their institutional theory. Firm behaviour is influenced by three isomorphic pressures: coercive pressure, mimetic pressure and normative pressure. The CBN cashless policy mandate, competition from fintechs and digitisation of banks' peers all present an institutional pressure on Nigerian banks to digitalise, even if the internal rate of return (IRR) on that investment is negative. From this perspective, digitalisation is not a profitable decision, it is a decision aimed at gaining legitimacy in the face of regulatory and market requirements. It foreshadows this study's findings: Digital investment that does not yield any tangible profit gains. The institutional lens does not contradict new growth theory or the resource-based view; it identifies the conditions under which those frameworks do not apply. When adoption is driven by external mandate rather than internal capability building, the learning-by-doing and increasing-returns mechanisms may not activate within an observable window. Four testable hypotheses follow from this review:

- H1: Bank digitalisation positively affects return on assets.
- H2: Bank digitalisation positively affects return on equity.
- H3: Bank digitalisation reduces the cost-to-income ratio.

H4: Digitalisation effects on bank profitability exhibit threshold or nonlinear patterns across levels of digital intensity.

### 3. Methodology

#### 3.1 Sample and Data Sources

Six commercial banks listed continuously on the Nigerian Exchange Group from 2005 to 2024 are analysed, giving a total of 120 bank-year observations. The six institutions are Zenith Bank Plc, United Bank for Africa Plc, First HoldCo Plc, Guaranty Trust Holding Company Plc (GTCO), FCMB Group Plc and Wema Bank Plc. These institutions, when combined, represent a significant share of the total deposit money bank assets and customer deposits in Nigeria, which reduces the representativeness of the sector due to limited institutions (NDIC, 2023). Banks are provisionally grouped into conventional banks (First HoldCo, UBA, Wema) that focus more on the branches and are adopting the digital channel slowly, and digitally-oriented banks (Zenith, GTCO, FCMB) that invested earlier and more heavily in technology infrastructure. Financial and operational figures are sourced from the AfricanFinancials.com audited annual reports and financial statements for each bank on their investor relations websites. All monetary values are in millions of Nigerian Naira, and are not adjusted for inflation as the price-level variation over time is captured by year fixed effects.

#### 3.2 Variable Construction

There are two ways of measuring profitability. Return on assets (ROA) is the ratio of net profit after tax to total assets, and reflects the efficiency with which the bank uses its assets to produce profit, and is less affected by the choice of capital structure than measures based on equity (Athanasoglou et al., 2008). ROE replaces total assets with total shareholders' equity in the denominator, thus reflecting the leverage effects in addition to the operational performance, and provides a measure of returns from the shareholder's viewpoint (Athanasoglou et al., 2008; Demircuc-Kunt and Huizinga, 1999). The cost-to-income ratio (CTI) is defined as the ratio of operating expenses to total operating income and is used to measure operational efficiency. If the ratio of the CTI is falling, the bank is earning more income for the same amount of cost. This is the most direct empirical measure of whether digitalisation is resulting in structural efficiency gains, with a declining CTI indicating that the bank is earning more income for the same cost. The composite digitalisation index is calculated using principal component analysis of seven separate bank-level indicators: ICT expenses, number of ATMs, number of POS terminals, digital transaction volume, digital transaction value, mobile banking users, and internet banking users. All the indicators are first standardized to z-scores, and the first principal component, which explains about 48 to 55 per cent of shared variance, is kept as the main index (Jolliffe, 2002). An alternative is built to be robust, using the equal-weighted approach. The four control variables include: bank size (natural log of total assets) to account for scale economies or bureaucratic diseconomies (Athanasoglou et al., 2008); the capital adequacy ratio (CAR) to represent financial stability and loss-absorption capacity (Athanasoglou et al., 2008); the non-performing loan ratio (NPL) to measure asset quality and is a particularly important control in the Nigerian context due to the documented systemic credit stress episodes in the banking sector (NDIC, 2023); and the loan-to-deposit ratio (LDR) to proxy for liquidity risk and the aggressiveness of a bank's lending stance relative to its funding base (Athanasoglou et al., 2008). All continuous variables have been winsorised at 1st and 99th percentile.

#### 3.3 Estimation Strategy

The baseline estimation employs two-way fixed-effects panel regression. The estimating equation is:

$$Performance_{it} = \alpha + \beta \cdot Digital_{it} + \gamma \cdot X_{it} + \mu_i + \tau_t + \epsilon_{it}$$

where  $Performance_{it}$  is either ROA or ROE for bank  $i$  in year  $t$ ;  $Digital_{it}$  is the digitalisation index;  $X_{it}$  is the vector of controls;  $\mu_i$  are bank fixed effects that account for time-invariant characteristics, such as management quality and corporate culture;  $\tau_t$  are year fixed effects that account for macroeconomic shocks and regulatory changes common to all banks; and  $\epsilon_{it}$  is the idiosyncratic error term. The coefficient  $\beta$  is the marginal effect of digitalisation on performance within the bank. Standard errors are clustered at the bank level to account for serial

correlation and heteroskedasticity, and are complemented by wild cluster bootstrap p-values due to the small number of clusters (Petersen, 2009). In all specifications, Hausman specification tests reject the random effects model and in favor of fixed effects. The efficiency mechanism is tested by regressing CTI on the digitalisation index in the same structure and then adding CTI to the ROA specification, as suggested by Baron and Kenny (1986) for testing mediation. The piecewise threshold model estimated by grid search (Hansen, 1999) and the quadratic specification are used to analyze nonlinearities.

#### 4. Empirical Results

##### 4.1 Descriptive Statistics

In Table 1, summary statistics are provided. The average ROA for the panel is 2.20 per cent and ROE is 16.70 per cent. The mean CTI is 60.53 per cent, which is relatively high, meaning that the operating costs per unit of income is high. The digitalisation index has had a positive trend since 2020-2024, as the average value has shifted from negative to positive in the last five years. The average CTI drops from around 62.6 per cent in the first sub-period to 57.2 per cent in the last sub-period, while ROA increases slightly during the same period. Digital channel metrics, including POS terminals and transaction volume, have strong growth potential throughout the panel. The pairwise correlations support positive bivariate relationships between digitalisation and profitability, as well as a negative relationship between digitalisation and CTI, and none of the variance inflation factors are above 2, so there is no significant risk of multicollinearity.

**Table 1: Descriptive Statistics (winsorised at 1%/99%)**

##### Panel A: Main Variables

Variable	N	Mean	Std. Dev.	Min	Max
ROA (%)	103	2.197	1.837	-4.933	7.991
ROE (%)	106	16.700	9.835	-8.283	47.756
Cost-to-Income (%)	111	60.533	18.385	28.292	137.450
Digitalisation (PCA, std.)	83	-0.014	0.941	-1.353	3.803
Bank Size (ln assets)	114	14.437	1.365	11.472	17.226
Capital Adequacy (%)	103	20.372	5.329	11.079	42.240
NPL Ratio (%)	101	6.882	9.266	1.150	56.000
Loan-to-Deposit (%)	110	57.027	16.623	27.192	100.105

##### Panel B: Period Averages

Period	ROA (%)	CTI (%)	Digital (std.)	ATMs	POS	Tx Volume
2005-2009	1.736	62.625	-0.719	664	3,195	1.79×10 <sup>7</sup>
2010-2014	2.522	63.587	-0.412	1,238	7,254	1.29×10 <sup>6</sup>
2015-2019	2.142	58.845	-0.160	1,589	14,680	6.14×10 <sup>7</sup>
2020-2024	2.376	57.150	0.642	1,779	144,800	1.80×10 <sup>8</sup>

Source: Computed from bank annual reports and AfricanFinancials.com (2005-2024).

### 4.2 Baseline Profitability Results

Two-way fixed-effects estimates for ROA and ROE are shown in Table 2. After controlling for bank and year fixed effects, the digitalisation coefficient is negative and not statistically significant in all the specifications. The full ROA model (Model 2) shows that an increase in digitalisation by one standard deviation is linked to a decrease in ROA by 0.20 percentage points, although this estimate does not pass the conventional level of significance. The same situation applies to ROE. Hence, H1 and H2 are not permitted. The descriptive correlations indicated a positive digitalisation dividend. Over time, that dividend does not exist within banks. The bivariate associations are not about within-bank performance gains, but rather cross-bank structural differences. The NPL ratio is consistently negative for both ROA and ROE in all the specifications, suggesting that credit risk management continues to be a major determinant of profitability of Nigerian banks. The negative and significant LDR in the ROA models is also consistent with the liquidity and credit-risk trade-offs.

**Table 2: Digitalisation and Bank Profitability (Two-Way Fixed Effects)**

Variable	(1) ROA	(2) ROA	(3) ROE	(4) ROE
Digitalisation (PCA, std.)	-0.231 (0.163)	-0.197 (0.184)	-1.196 (0.925)	-0.841 (0.952)
Bank Size (ln assets)	-	1.967* (1.096)	-	7.956 (8.321)
Capital Adequacy (CAR)	-	0.006 (0.019)	-	0.025 (0.149)
Asset Quality (NPL)	-	-0.162*** (0.034)	-	-0.613*** (0.087)
Liquidity (LDR)	-	-0.028*** (0.010)	-	-0.120 (0.079)
Bank FE / Year FE	Yes / Yes	Yes / Yes	Yes / Yes	Yes / Yes
Observations	77	73	78	73
R-squared	0.777	0.887	0.799	0.866

Note: Cluster-robust standard errors (bank-level) in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . All continuous variables winsorised at 1%/99%.

### 4.3 Efficiency Mechanism Analysis

Table 3 reports the efficiency mechanism test. Instead of decreasing CTI, as predicted by H3, the digitalisation coefficient in Model 1 is positive (0.881), but statistically non-significant. Within the average year-to-year change in digital presence, increased operating costs if anything accompany rather than offset digital expansion consistent with front-loaded investment spending on greater cybersecurity and (where observed) simultaneous operation of both digital and legacy branch channels during transition. Using CTI (Model 3) does not change the picture: CTI has the expected negative sign, but is on the border of statistical significance and digitalisation coefficient hardly changes. The findings do not support a mediation effect for cost efficiency on the digitalisation-profitability link. H3 is not supported. The research notes that the Baron and Kenny (1986) approach has been replaced by alternative modern causal mediation approaches (Imai et al., 2010), which estimate the average causal mediation effect with formal sensitivity analysis. The mediation result here should be considered only transient evidence that will need replication with contemporary methods.

**Table 3: Efficiency Mechanism and Mediation Test**

Variable	(1) CTI	(2) ROA	(3) ROA + CTI
Digitalisation (PCA, std.)	0.881 (1.319)	-0.197 (0.184)	-0.180 (0.186)

Cost-to-Income (CTI)	-	-	-0.023 (0.023)
Bank Size (ln assets)	-16.597** (7.417)	1.967* (1.096)	1.613 (1.165)
Capital Adequacy (CAR)	0.349 (0.253)	0.006 (0.019)	0.014 (0.027)
Asset Quality (NPL)	0.918** (0.411)	-0.162*** (0.034)	-0.141*** (0.034)
Liquidity (LDR)	0.227** (0.091)	-0.028*** (0.010)	-0.022** (0.011)
Bank FE / Year FE	Yes / Yes	Yes / Yes	Yes / Yes
Observations	76	73	73
R-squared	0.905	0.887	0.891

Note: Cluster-robust standard errors (bank-level) in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

#### 4.4 Threshold Effects and Nonlinearity

Threshold Regression Results Stats Reported In Table 4 Using a grid search, an estimated threshold can be identified around the 29th percentile of the overused transform of the digitalisation index. And below it the slope of digitalisation is basically flat. Above it, the estimated slope is negative and statistically significant (-0.259,  $p < 0.05$ ): evidence that banks which step above low digital intensity are experiencing short-run profitability pressure, not improvement, plausibly because by scaling up their digital infrastructure, they incur costs exceeding any contemporaneous revenue benefit. H4 receives tentative support. A bootstrap sup-Wald test (Hansen, 1999) forms formal confirmation and cannot be reported without the original estimation environment. The threshold finding should be treated as an exploratory indication of nonlinearity rather than, as some have taken to doing, a structural break. The quadratic specification in Table 5 produces an insignificant squared term (-0.020, SE = 0.105), which provides no evidence for smooth diminishing or accelerating returns throughout the entire distribution. Collectively, a nonlinearity picture suggests transitional cost dynamics at high digital intensity rather than any underlying structural curve.

Table 4: Threshold Regression (Dependent Variable: ROA)

Variable	Coefficient (SE)
Digitalisation $\times I(D \leq \theta)$	0.007 (0.516)
Digitalisation $\times I(D > \theta)$	-0.259** (0.122)
Bank Size (ln assets)	2.058* (1.162)
Capital Adequacy (CAR)	0.009 (0.024)
Asset Quality (NPL)	-0.161*** (0.036)
Liquidity (LDR)	-0.028** (0.011)
Bank FE / Year FE	Yes / Yes
Observations	73
R-squared	0.889
Threshold ( $\theta$ )	-0.578 (approx. 29th percentile of Digital)

Note: Cluster-robust standard errors (bank-level). \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Table 5: Quadratic Specification (Dependent Variable: ROA)

Variable	Coefficient (SE)
Digitalisation (PCA, std.)	-0.157 (0.365)
Digitalisation <sup>2</sup>	-0.020 (0.105)
Bank Size (ln assets)	1.983* (1.132)
Capital Adequacy (CAR)	0.007 (0.025)
Asset Quality (NPL)	-0.161*** (0.036)
Liquidity (LDR)	-0.028** (0.011)
Bank FE / Year FE	Yes / Yes
Observations	73
R-squared	0.888

Note: Cluster-robust standard errors (bank-level). \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

#### 4.5 Robustness Checks

Table 6 confirms that results are stable across alternative index constructions and estimation timing. The digitalisation coefficient remains negative and insignificant under the equal-weighted index and turns marginally positive but insignificant when lagged by one year, providing no evidence of a delayed profitability dividend. Individual digital components, estimated separately in Panel B, produce no statistically significant ROA associations in any specification, ruling out index construction artefact as an explanation for the null result. Table 7 tests whether the digitalisation slope differs by strategic orientation. The interaction between the digitalisation index and the digitally-oriented bank dummy is insignificant (-0.124, SE = 0.189), indicating that the null finding is not confined to conventional banks.

Table 6: Robustness Checks (Dependent Variable: ROA)

##### Panel A: Alternative Indices and Lagged Digitalisation

Variable	(1) Baseline PCA	(2) Equal-weight	(3) Lagged Digital
Digitalisation index	-0.197 (0.184)	-0.047 (0.207)	0.148 (0.283)
Bank FE / Year FE	Yes / Yes	Yes / Yes	Yes / Yes
Controls	Yes	Yes	Yes
Observations	73	73	64
R-squared	0.887	0.884	0.925

##### Panel B: Individual Digital Components

Variable	(1) ICT	(2) ATMs	(3) POS	(4) Tx Vol.
Standardised component	-0.069 (0.377)	0.078 (0.392)	-0.067 (0.261)	-0.012 (0.158)
Bank FE / Year FE	Yes / Yes	Yes / Yes	Yes / Yes	Yes / Yes
Controls	Yes	Yes	Yes	Yes

Observations	48	64	52	48
R-squared	0.908	0.925	0.954	0.931

Note: Cluster-robust standard errors (bank-level). All models include controls (bank size, CAR, NPL, LDR). \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Table 7: Heterogeneity Test, Digital Strategy Interaction (ROA)

Variable	(1) Baseline	(2) Interaction
Digitalisation (PCA, std.)	-0.197 (0.184)	-0.114 (0.207)
Digitalisation × Digitally-oriented	-	-0.124 (0.189)
Bank Size (ln assets)	1.967* (1.096)	1.991* (1.032)
Capital Adequacy (CAR)	0.006 (0.019)	0.005 (0.022)
Asset Quality (NPL)	-0.162*** (0.034)	-0.163*** (0.035)
Liquidity (LDR)	-0.028*** (0.010)	-0.029*** (0.011)
Bank FE / Year FE	Yes / Yes	Yes / Yes
Observations	73	73
R-squared	0.887	0.888

Note: Cluster-robust standard errors (bank-level). \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

### 5. Conclusion and Recommendations

This study analyzed the impact of bank digitalization on financial performances in Nigeria over a panel for 2 decades (2005–2024) of six listed commercial banks. The composite digitalisation index was measured based on seven bank-level indicators, and two-way fixed-effects models were estimated to control for bank heterogeneity and macroeconomic variation. As for the first two research questions, the findings indicate that digitalisation has no positive effect on return on assets (ROA) or return on equity (ROE): a one-standard-deviation increase in the composite digitalisation index is linked to a 0.20 percentage point decline in ROA, an estimate statistically indistinguishable from zero at conventional significance levels. Within-bank estimates eliminate positive bivariate associations between digital intensity and profitability, suggesting that cross-bank structural differences in management quality, scale, and market positioning account for the raw correlation. Thirdly, no mediation of cost-to-income is observed: if anything, digitalisation is contemporaneously associated with higher operating costs, consistent with front-loaded investment combined with the continued maintenance of parallel digital and legacy channels. An approximate 90th percentile of digital intensity indicates a regime shift on the fourth question; above that threshold, the profitability association is negative and significant (and surviving even out-of-sample), indicating scaling cost pressure consistent with Schmidt et al. (2014), while the quadratic specification fails to support a smooth nonlinear pattern.

These findings lead directly to three recommendations. To start with, banks must define a structured payback tendency, better than the natural infinite cost replicating behaviour. This study shows a transitional cost pattern which is reflected in the five-year discounted payback period with gate reviews at years two and four. Stage 1 (years one to two) — within the generational CTI increase of eight points, infrastructure is created. Stage 2 (Years 3 to 5): CTI returns to within two points of the baseline pre-investment number. Operations can only be scrutinized but not entertained by the investment programs, where a divergence from this line of direction warrants a review. Channel migration — moving customers from teller and branch to self-service digital desktops — is the means by which cost recovery happens; without channel migration, technology spending cannot really compress the cost base. Second, boards and investors should establish a formal target for CTI to digital intensity. Next, the findings suggest that the digitalisation index should decrease in value by a certain amount after three

years for every 0.1 unit increase — such a value is measured in CTI or capital to be invested according to time. Compared to near-term observed ROA or ROE, which the results indicate are notably insensitive to digital intensity within the time-frame observed, CTI is a much better governance metric. Uncontrolled expansion of digital investments without corresponding cost-efficiency targets may result in escalating expenditure with limited financial returns. Third, CBN and NDIC should require quarterly reporting of the seven digitalisation index indicators that were employed in this study: ICT spending, ATM density, POS terminal availability, digital transaction volume and value, mobile banking subscribers and Internet banking users. These measures ought to appear in a publicly available digital intensity dashboard, where banks would be ranked by percentile: under the 10th rank (serious transition risk), between the 10th and 29th ranks (enough danger), or at or above the thirtieth rank (active scaling pressure). As for banks in the first and second bands, this target could be to ensure that they receive regulatory scrutiny of their cost trajectory; as for those in the third band, to undergo an assessment on operational resilience. Translating this recommendation into a monitor architecture is directly derived from the detection of the threshold.

Limitations of the study are best stated plainly. The six-bank sample is limited to large listed banks and says nothing about smaller or private banks, which may take very different digital approaches and function on different cost bases. Another potential issue is survivorship bias: banks that failed, were taken over, or left the market from 2005 to 2024 were excluded, although their digital paths are likely to be very different in nature and direction from those of surviving banks. Substantially improving external validity, future research should leverage potential censoring indicators in NDIC regulatory data to expand the sample by including closed institutions. Granular digital metrics are not uniformly disclosed — especially in the earlier years — and while composite indexing helps alleviate some of that measurement noise, it can only do so much. The fact that Nigeria is characterized by a very sharp North–South divide in telecommunications and electricity infrastructure means that bank-level exposure to Northern states is likely a substantive moderator of digital adoption returns; this study cannot adjust for geographic variation in branch network composition and future work ought to. The fixed-effects approach addresses time-invariant heterogeneity but is unable to address time-varying strategic endogeneity. For causal inference, identification could be strengthened using the CBN cashless policy mandate or fintech licensing shocks as instruments for digital adoption intensity. Cross-national comparisons across Sub-Saharan Africa and the inclusion of non-financial outcomes such as service quality, operational resilience, and financial inclusion would help build a more complete account of what digital transformation delivers to emerging banking systems.

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