Digital Innovations and Performance of Commercial Banks in South Sudan.

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ABSTRACT

This study examined the effect of digital innovations namely mobile banking, internet banking, ATM and card services, and FinTech integration on the performance of commercial banks in South Sudan, with bank performance operationalized as customer deposit growth. Despite a regional and global shift toward digital banking as a driver of efficiency, profitability, and financial inclusion, commercial banks in South Sudan continue to record weak performance, evidenced by a return on assets below 0.5 percent, a cost-to-income ratio above 75 percent, and customer deposit growth of only 4.2 percent between 2020 and 2022, well below the East African regional average of 12.6 percent. Whether and how digital innovation translates into measurable performance gains in this fragile, post-conflict banking environment remains empirically under-investigated. The study adopted a correlational research design and a longitudinal panel data approach covering 2019–2025. The target population comprised all 31 licensed commercial banks in South Sudan, surveyed through a census approach. After data cleaning, a balanced panel of 117 bank-year observations from 17 banks with complete records was retained. Secondary data were extracted from audited bank financial statements and Bank of South Sudan publications, and analyzed using a Fixed Effects panel regression model with robust standard errors in Stata. Mobile banking had a positive and statistically significant effect on customer deposit growth ($\beta = 0.826$, $p < 0.000$); internet banking had a positive and statistically significant effect ($\beta = 0.056$, $p < 0.000$); ATM and card services had a negative and statistically insignificant effect ($\beta = -0.025$, $p = 0.612$); and FinTech integration had a positive but statistically insignificant effect ($\beta = 0.230$, $p = 0.242$). The model explained approximately 87.0 percent of the variation in customer deposit growth ($R^2 = 0.870$, $F = 645.92$, $p < 0.000$). Mobile banking and internet banking are significant drivers of customer deposit growth and, by extension, bank performance in South Sudan, while ATM and card services and FinTech integration have not yet produced statistically significant effects, largely owing to infrastructural, regulatory, and technological-readiness

constraints.

Introduction

Commercial banking activity worldwide has grown increasingly volatile, shaped by economic shocks, technological change, and shifting consumer preferences (Nejad, 2022). Digital innovation has emerged as a key strategic lever for performance improvement, yet banking sectors across the globe continue to struggle with inefficiencies in profitability, asset quality, and cost of operations (Khalifaturofi'ah, 2021). The International Monetary Fund (2023) reported that average return on assets (ROA) for commercial banks in developed economies fell from 1.2 percent in 2018 to 0.6percent in 2021, despite rising digital transformation expenditure. Global banks spent over US$500 billion on information technology in 2022 alone (World Bank, 2022), yet a McKinsey (2022) review found that 70percent of digital transformation projects in banking fail to deliver expected results, largely due to misaligned strategy or outdated infrastructure. Maintaining performance amid digital innovation therefore remains a live concern even in the most developed banking markets.

In Sub-Saharan Africa, performance challenges are compounded by infrastructural gaps, regulatory instability, and limited innovation diffusion. The African Development Bank (AfDB, 2021) reported a regional average non-performing loan ratio of 7.2 percent in 2020, well above the global average of 4.5 percent, alongside a regional average Return on Equity of 11 percent against a global benchmark of 13 percent. These performance gaps persist even where mobile banking, agency banking, and core banking systems have been adopted, as in Kenya, Nigeria, and Ghana. This raises questions about the effectiveness, flexibility, and strategic alignment of digital innovation within African financial institutions.

South Sudan presents a more critical case. Although commercial banks have taken incremental steps toward digital adoption including mobile banking and point-of-sale services overall bank performance remains weak. The Bank of South Sudan (BOSS, 2023) reports that over 60percent of the adult population remains unbanked, with less than 15percent of transactions conducted digitally. Most banks record ROA below 0.5 percent and cost-to-income ratios exceeding 75 percent, indicating substantial inefficiency. A joint FSD Africa and BOSS Financial Sector Diagnostic Report (2023) found that domestic deposit mobilization by commercial banks grew by only 4.2percent between 2020 and 2022, compared to a regional average of 12.6 percent, while the loan-to-deposit ratio stood at a mere 23 percent, which is evidence of weak intermediation that has constrained private sector development and limited the banking sector's contribution to GDP to less than 2.5 percent, among the lowest in East Africa (FSD Africa, 2023).

Deng and Lado (2022) attribute the sector's weak performance to underdeveloped ICT infrastructure, low digital literacy, and regulatory bottlenecks that persist despite the introduction of digital tools. Many banks continue to rely on manual processes and lack integrated core banking solutions, with liquidity cover ratios remaining unstable. This pattern points to a structural underperformance in which digital innovation has not yet translated into measurable gains in

financial stability, outreach, or profitability. This is a gap that policy and managerial interventions cannot meaningfully address without dedicated empirical investigation.

Bank Performance and Digital Innovation

Berger and Bouwman (2020) define bank performance as the degree to which a bank attains its financial, operational, and strategic objectives, particularly profitability, efficiency, risk management, and customer service. Adusei and Obeng (2021) similarly link bank performance to the sustainability of financial health, stakeholder value growth, and resilience to environmental change. This study adopts the Balanced Scorecard (BSC) framework's multidimensional view of performance (Kaplan & Norton, 1996), which is particularly suited to fragile or post-conflict economies such as South Sudan, where profitability metrics alone may not reliably capture institutional health amid macroeconomic instability (Mustafa, 2021). Rather than relying on traditional ROA, ROE, or Net Interest Margin measures, which can be distorted by inflation, exchange-rate volatility, and capital constraints common in post-conflict settings. This study measures bank performance through customer deposit growth, an indicator of market confidence and service quality that is closely tied to digital innovation (Ozili, 2022; Galleta et al., 2020; Winarto & Susan, 2020).

Bank innovation refers to the development and deployment of new or significantly improved technologies, processes, or service models intended to enhance banking operations, customer experience, and financial inclusion (Alam & Raut-Roy, 2021; Ozili, 2022). Donou-Adonsou (2021) identifies mobile banking, internet banking, ATM and card services, and FinTech integration as the principal dimensions of bank innovation relevant to developing economies. Mobile banking enables real-time financial services and reduces dependence on physical branch infrastructure. This is a critical advantage in low-infrastructure economies like South Sudan (Koksal, 2021; Oludele & Sylvester, 2022); empirical studies in East Africa link it to improved deposit mobilization and ROA (Kinyua & Okibo, 2021; Donou-Adonsou, 2021). Internet banking extends service delivery beyond branch walls and has been linked to improved profitability and retention, especially where contactless service became essential post-pandemic (Ahmad et al., 2022; Tadesse & Abera, 2022). ATM and card services support transaction speed and customer autonomy, with positive links to ROA and cost-efficiency documented in Ghana and Kenya (Isshaq & Bokpin, 2020; Mwangi & Ochieng, 2021). FinTech integration encompassing mobile wallets, peer-to-peer platforms, and data-driven analytics layered onto conventional banking has been associated with improved customer acquisition and cost-to-income outcomes in Asian markets (Arner et al., 2020), though its maturity in fragile economies remains limited.

Commercial Banks in South Sudan

South Sudan's banking sector remains nascent and fragile. As of 2023, the Bank of South Sudan licensed 31 commercial banks, most concentrated in Juba with limited rural coverage; only 15 percent of South Sudanese adults have access to formal financial services (IMF, 2024), and private-sector credit constitutes less than 5 percent of GDP (BoSS, 2023). Average ROA has remained below 0.5 percent, cost-to-income ratios above 75 percent, and non-performing loan ratios between 17 percent and 38 percent, which is far above the regional average (Bank of South Sudan, 2023; World Bank, 2023). Deposit growth averaged just 4.2 percent between 2020 and 2022 against a regional average of 12.6 percent (FSD Africa, 2023), compounded by hyperinflation, exchange-rate instability, political insecurity, and weak regulatory enforcement (IMF, 2024).

Despite these constraints, South Sudanese banks have begun adopting digital tools such as mobile banking, POS systems, debit cards, and rudimentary internet banking portals alongside emerging FinTech partnerships with mobile network operators (Kordit, 2022). However, adoption remains uneven and fragmented due to infrastructural deficits, low digital literacy, and inconsistent regulation (FSD Africa & BoSS, 2023). Whether these initiatives have produced measurable improvements in bank performance, particularly customer deposit growth as an indicator of institutional trust and liquidity, remains empirically untested the gap this study seeks to close.

Statement of The Problem

Commercial bank performance in South Sudan remains weak despite the global and regional shift toward digital technologies as drivers of efficiency, profitability, and financial inclusion. The sector records a return on assets below 0.5 percent, cost-to-income ratios above 75 percent, and deposit growth of just 4.2 percent in 2020–2022 (BoSS, 2023; FSD Africa, 2023) evidence of inefficiency, weak liquidity, and limited integration into South Sudan's economic development agenda. This is particularly concerning in a post-conflict context where a functioning banking sector is essential for mobilizing savings, enabling investment, and advancing financial inclusion. While ATM services, mobile banking, internet banking, and FinTech have improved banking sector performance elsewhere in Sub-Saharan Africa (Donou-Adonsou, 2021; Alhassan & Asamoah, 2022), their role in South Sudan remains unclear, fragmented, and empirically under-investigated.

Despite efforts by banks in Juba to deploy mobile banking systems, POS infrastructure, and limited online banking platforms, operational and financial performance has not improved correspondingly (Kordit, 2022). Many banks continue to grapple with low customer adoption, weak service infrastructure, and limited internal capacity to leverage digital systems effectively contributing to stagnant or declining customer deposit growth, loan-to-deposit ratios, and financial returns. Left unaddressed, this trend risks eroding public confidence, reducing investor confidence, and excluding large segments of the population from formal financial services, with consequences for economic recovery and the government's ability to leverage the financial sector for stabilization and development.

Significant contextual, conceptual, and methodological gaps persist in the literature linking digital innovation to bank performance. Much of the existing Sub-Saharan African literature associates digital innovation with profitability metrics (ROA, ROE, Net Interest Margin) while overlooking customer deposit mobilization arguably a more critical performance indicator in fragile economies where trust and liquidity are paramount. Studies by Ghosh (2021), Tadesse and Abera (2022), and Donou-Adonsou (2021) focus on profitability outcomes in relatively stable Sub-Saharan settings, omitting deposit growth as a measure of customer confidence and liquidity strength. Moreover, prior research has concentrated on relatively stable markets such as Kenya, Nigeria, and Ghana, with little empirical attention paid to South Sudan, where institutional inefficiencies, political instability, and infrastructural deficits shape digital adoption differently. This study addresses these gaps by assessing how mobile banking, internet banking, ATM and card services, and FinTech integration influence customer deposit growth among commercial banks in South Sudan.

Objectives of the Study

The general objective of the study was to establish the effect of digital innovations on the performance of commercial banks in South Sudan. The specific objectives were:

- To evaluate the effect of mobile banking on the performance of commercial banks in South Sudan.
- To analyze the effect of internet banking on the performance of commercial banks in South Sudan.
- To determine the effect of ATM and card services on the performance of commercial banks in South Sudan.
- To analyze the effect of FinTech integration on the performance of commercial banks in South Sudan.

Theoretical Foundations

Innovation Diffusion Theory

Rogers' (1995) Innovation Diffusion Theory holds that an idea spreads through a social group via specific communication channels, with adoption speed shaped by five characteristics: relative advantage, compatibility, complexity, trialability, and observability. The theory is highly relevant to technology adoption in banking, explaining how innovations such as mobile money transfer migrate from telecommunications into banking to improve service delivery and accessibility. Keskar and Pandey (2018) caution that the model describes adoption patterns rather than performance outcomes, and its explanatory power has not been fully tested in weak economies like South Sudan, where sector performance is shaped by structural and institutional deficits. Nonetheless, the theory underpins this study's expectation that banks adopting digital channels such as ATMs, POS terminals, and online platforms gain a competitive advantage in cost-efficiency and profitability (Alharafsheh & Alghizzawi, 2021), with empirical work confirming that internet banking intensity is positively associated with bank profitability (Ghose & Maji, 2022) and

that customer trust and commitment shape continued usage of digital banking platforms (Rahi et al., 2021).

Transaction Cost Innovation Theory (TCIT)

Building on Coase (1937) and Williamson's (1975, 1985) Transaction Cost Economics, TCIT explains technology adoption as a strategy for reducing the search, coordination, and enforcement costs inherent in economic exchange. Innovations such as e-banking and ATMs are theorized to minimize transaction friction and enhance efficiency and performance. Critics note that TCIT's narrowly economic lens can underweight social, behavioural, and institutional dimensions of technology adoption, and presumes a purely rational, efficiency-driven decision process that may not hold where infrastructure and digital literacy are limited (Langlois, 2007; Ghoshal & Moran, 1996). In this study, TCIT provides the theoretical basis for expecting South Sudanese banks to adopt mobile banking, internet banking, ATM, and FinTech tools as cost-reduction strategies that lower the costs of manual processing, branch-based service, and cash handling consistent with evidence that mobile banking adoption in Kenya and ATM/POS deployment in Sub-Saharan Africa reduced transaction and coordination costs (Matoke & Omwenga, 2016; Nyasha & Odhiambo, 2020).

Technology Acceptance Model (TAM)

Davis (1986) Technology Acceptance Model, extending the Theory of Reasoned Action, holds that the intention to use new technology is shaped by perceived usefulness (PU) and perceived ease of use (PEOU). Although criticized for under-weighting cultural, social, and infrastructural variables relevant in developing countries, and for focusing on individual rather than organizational or systemic adoption forces (Bagozzi, 2007; Lee et al., 2003), TAM remains useful for modelling how customer-facing technologies such as mobile and internet banking drive deposit growth: the more useful and accessible customers perceive these channels to be, the greater their adoption and the resulting deposit mobilization. Empirical applications confirm that PU and PEOU are robust predictors of mobile banking adoption in Jordan (Alalwan et al., 2021), that perceived ease of use predicts customer loyalty to internet banking in Sub-Saharan Africa (Shaikh & Karjaluoto, 2020), and that behavioural perceptions shape digital banking engagement in Ethiopia (Tadesse & Abera, 2022).

Balanced Scorecard (BSC) Model

Kaplan and Norton's (1996) Balanced Scorecard widens performance measurement beyond financial results to encompass customer perspectives, internal processes, and organizational learning and growth. Its customer-focused dimension is particularly relevant to banking, where customer trust and loyalty which is reflected in deposit growth directly underpin

financial success (Slater & Narver, 2000; Heskett et al., 1994; Reichheld, 2003). Critics note that the BSC's data and managerial-capacity requirements can be difficult to meet in resource-constrained institutions, and that its multi-perspective approach can create confusion where supporting infrastructure is weak (Malina & Selto, 2001; Otley, 1999; Neely et al., 2002) a caution directly relevant to South Sudanese banks. Even so, the BSC's customer-deposit-oriented, long-term strategic view justifies this study's choice of customer deposit growth as the principal performance measure, provided contextual constraints are explicitly acknowledged (Niven, 2006; Parmenter, 2015).

Similar Studies

Abbasi and Weigand (2017) synthesis of over forty peer-reviewed studies found mobile banking generally improves operational efficiency, customer retention, and revenue generation, though effects vary with market maturity, infrastructure, and customer trust with most underlying studies drawn from developed or middle-income economies, limiting applicability to fragile states. In South Sudan specifically, Kordit (2022) surveyed employees of 31 licensed banks in Juba and found mobile banking improved customer satisfaction and operational efficiency but explained only 19.3 percent of variance in performance measures, constrained by weak infrastructure, limited skilled manpower, and low public trust in digital tools. Chimanga and Kawimbe (2024), surveying 101 customers of a Zambian bank, found mobile banking significantly improved customer satisfaction and profitability, a pattern echoed in Ghana and Nigeria, though these studies relied on customer perception data rather than objective deposit figures. Chebii et al. (2024), using mixed methods with 150 respondents from Nairobi banks, found mobile banking improved transaction costs, deposits, and customer base size when integrated with core banking systems, though cybersecurity risk and regulatory rigidity remained barriers. Collectively, these studies support a positive mobile banking–performance relationship but leave a gap in objective, deposit-based evidence from fragile, low-infrastructure markets such as South Sudan. This is the gap this that the current study addresses.

Wol (2019), surveying 92 bank managers across 24 South Sudanese commercial banks, found internet banking strongly and positively correlated with profitability, retention, and operational efficiency, particularly where it was integrated with broader strategic goals. However, the study relied on subjective managerial perception rather than objective financial data. Owuor (2021), using panel regression on audited records of 40 Kenyan banks (2017–2020), found e-banking explained up to 95.5 percent of variance in bank performance (adjusted $R^2 = 0.955$), with internet banking driving non-interest income and efficiency gains, though again without examining deposit mobilization specifically. Sathye (2023), in a ten-year panel study of Australian credit unions, found a robust long-term link between internet banking and improved ROA and cost-to-income ratios, but in a high-income, digitally mature setting far removed from South Sudan's context. Kavila and Kilika (2023), examining 39 Kenyan banks (2016–2020) with fixed- and random-effects models, found internet banking positively but not significantly associated with ROA and ROE, attributing the weak effect to low penetration and connectivity without considering deposit-based performance measures. These studies collectively justify the present study's use of a quantitative panel design

with objective deposit data over a longer (2019–2025) window specific to South Sudan.

Abu-Shanab (2017), surveying Jordanian bank customers, found ATM and debit card services significantly improved operational performance and customer retention, particularly where banks invested in large ATM networks and real-time processing. Abayomi et al. (2019), surveying over 300 customers across five Nigerian banks, found ATM use improved satisfaction and reduced banking-hall congestion, though card fraud and frequent machine breakdowns undermined trust; Munywoki (2020) similarly found ATM availability improved satisfaction and cost savings. Mutua and Rotich (2021), using panel regression on twelve Kenyan banks (2016–2020), found ATM transactions positively influenced net income and ROE, especially when complemented by digital literacy and multifunctional cards; Okello and Namulinda (2018) found similar gains in Ugandan urban markets with extensive ATM networks. In South Sudan, Ladu's (2021) case study of two Juba banks found ATMs reduced branch congestion but suffered from downtime, poor maintenance, and unreliable network infrastructure, undermining service delivery and customer confidence. However, the study did not examine quantifiable deposit patterns. This study extends Ladu's (2021) work using a seven-year quantitative panel across a larger sample of South Sudanese banks.

Vives (2017) found that FinTech adoption blockchain, API platforms, data analytics improves operational efficiency and financial inclusion while pressuring banks to innovate or risk competitive displacement; a systematic review of 105 studies by Milian, Spinola, and Carvalho (2019) similarly linked FinTech adoption (automated credit scoring, chatbots) to faster service and improved market penetration, though both noted significant integration costs and cybersecurity concerns without isolating deposit-specific effects. Ozili (2018), examining Nigeria, Kenya, and South Africa, found FinTech improves access and revenue diversification but is constrained by infrastructure, consumer confidence, and institutional inertia; Yiga and Musoke (2021) similarly found mobile wallets and robo-advisory tools improved performance only in Ugandan banks with prior ICT investment and staffing capacity. Wambua and Mweru (2020), using panel data on 33 Kenyan banks (2015–2019), found a strong positive fintech–performance relationship, especially among banks with in-house fintech solutions, while Ndunda and Kibiru (2022) found biometric authentication and digital lending tools strengthened operational resilience during COVID-19. In South Sudan specifically, Laddu and Tongun (2022) qualitative study of Juba banks identified institutional unpreparedness, technological capacity gaps, and regulatory ambiguity including the absence of digital banking law, cybersecurity practice, and platform investment as the principal barriers to FinTech integration, though without empirically testing performance effects. This study closes that gap through a quantitative panel assessment of FinTech integration's effect on deposit growth.

Conceptual Framework

The conceptual framework is guided by the assumption that advancements in financial technology and digital platform adoption influence bank performance indicators, particularly customer deposit growth. Digital innovation is operationalized through four dimensions: mobile banking (annual volume of mobile banking transactions), internet banking (annual volume of online fund transfers), ATM and card services (annual value of ATM transactions), and FinTech integration

(annual number of customers using FinTech-integrated services). Bank performance is is operationalized as annual customer deposit growth. The framework proposes that each dimension of digital innovation independently and positively influences customer deposit growth by improving service accessibility, transaction convenience, operational efficiency, and customer trust, consistent with Innovation Diffusion Theory, Transaction Cost Innovation Theory, the Technology Acceptance Model, and the Balanced Scorecard Model reviewed above.

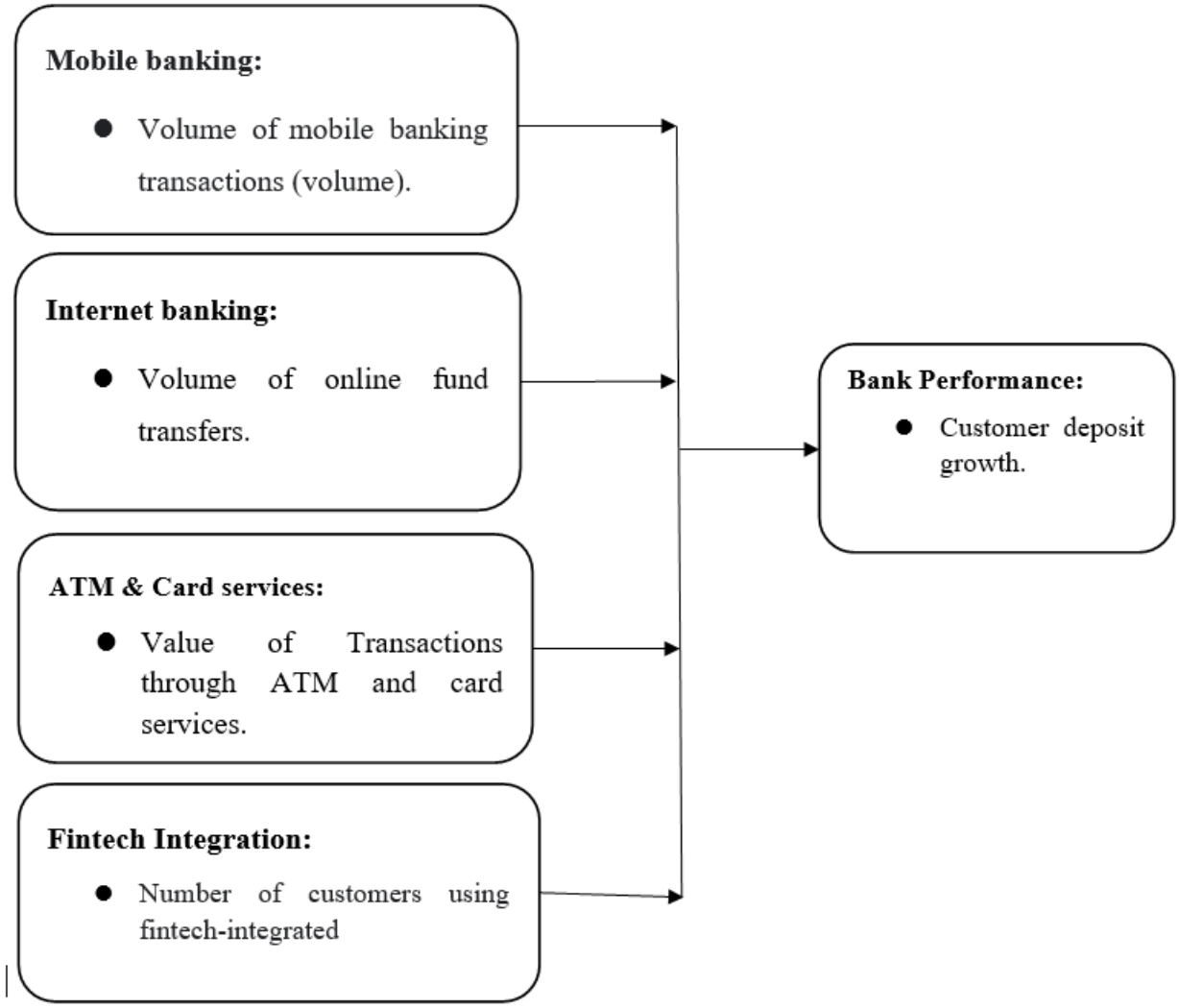

Figure 1: Conceptual Framework. Source: Author (2026)

Methods

The study adopted a correlational research design, appropriate for quantitative data analysis that evaluates relationships among variables without manipulating them, while establishing the strength and direction of association (Pyrczak, 2018; Curtis et al., 2016). This design suited the study's use of secondary panel data spanning 2019–2025 and its application of panel regression

analysis to test the stated hypotheses. The study employed a linear panel regression model, chosen for its capacity to control for unobservable heterogeneity across banks and over time, improving estimation accuracy and reducing omitted-variable bias (Baltagi, 2021):

$$Y_{it} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eqn\ 1)$$

Where Y represents bank i's performance at time t, measured through customer deposit growth; X1 denotes mobile banking adoption; X2 represents internet banking usage; X3 represents ATM and card service usage; X4 refers to the degree of FinTech integration; β0 is the constant term; β1 through β4 are coefficients; and ε is the error term. Variable selection was informed by prior empirical work (Wambua & Mweru, 2020; Mutua & Rotich, 2021; Milian et al., 2019), and the Hausman specification test determined the choice between fixed- and random-effects estimators (Greene, 2020).

Table 1: Operationalization of the Variables

Variable	Type	Operationalization	Measurement
Bank Performance	Dependent	Annual customer deposits	Ratio scale
Mobile Banking	Independent	Annual volume of mobile banking transactions	Ratio scale
Internet Banking	Independent	Annual volume of online fund transfers	Ratio scale
ATM & Card Services	Independent	Annual value of ATM transactions	Ratio scale
FinTech Integration	Independent	Annual number of customers using FinTech-integrated services	Ratio scale

Source: Author (2026)

The target population comprised all 31 licensed commercial banks operating in South Sudan, used as the units of analysis. Given the manageable population size, a census approach was adopted, in which all 31 banks were targeted for data collection over the seven-year period 2019–2025 (Yin, 2013). The study relied entirely on secondary data drawn from the audited annual financial reports of the 31 licensed commercial banks, supplemented by Bank of South Sudan publications and other authoritative institutional sources. A structured secondary data collection sheet was used to systematically extract and organize data on customer deposits, mobile banking transaction volumes, internet banking transfer volumes, ATM transaction values, and FinTech-integrated customer counts for each bank-year, ensuring consistency, completeness, and verifiability while avoiding the response bias inherent in primary data collection (Saunders, Lewis & Thornhill, 2019).

Data were analyzed using Stata 16 and Microsoft Excel, combining descriptive statistics with inferential panel regression analysis. Prior to estimation, all variables were log-transformed, and a series of diagnostic tests were conducted to verify the statistical assumptions underlying panel regression: normality (Jarque-Bera test), multicollinearity (Variance Inflation Factor), heteroskedasticity (Modified Wald test), autocorrelation (Wooldridge test), stationarity (Fisher-type panel unit root test), linearity/specification (link test), and model selection (Hausman

specification test). Robust standard errors were applied throughout to correct for heteroskedasticity and autocorrelation where detected (Greene, 2020).

Results

Of the 31 commercial banks targeted at the proposal stage, 6 had closed operations or had not published financial statements, 5 had incomplete digital innovation data, and 3 had no published or submitted financial statements. The final sample comprised a balanced panel of 117 bank-year observations from 17 commercial banks with complete and consistent data over 2019–2025. This sample size is methodologically adequate for panel regression: estimation techniques can yield reliable and efficient estimates even with a relatively small number of cross-sectional units provided observations are repeated over time (Baltagi, 2021), and the observation-to-predictor ratio comfortably exceeds the commonly recommended 15–20 observations per predictor (Hair et al., 2019).

Descriptive Statistics

Table 2 presents descriptive statistics for customer deposits (CD), volume of mobile banking transactions (VMBT), volume of online transfers (VOT), volume of ATM transactions (VATM), and number of customers using FinTech-integrated services (CFinT), all reported in South Sudanese Pounds (SSP) except CFinT.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Customer Deposits (CD)	117	36,200,000,000	84,700,000,000	2,494,400	647,500,000,000
Mobile Banking Transactions (VMBT)	117	161,000,000	381,000,000	11,225	2,914,000,000
Online Transfers – Internet Banking (VOT)	117	10,500,000,000	24,200,000,000	698,432	181,300,000,000
ATM Transactions (VATM)	117	53,900,000	127,000,000	3,742	971,300,000
FinTech-Integrated Customers (CFinT)	117	190,000	478,000	100	4,133,061

Source: Secondary Data (2019–2025)

Customer deposits averaged SSP 36.2 billion, with a high standard deviation (SSP 84.7 billion) and a wide range (SSP 2.49 million to SSP 647.5 billion) reflecting substantial disparities in institutional size, customer confidence, and market penetration among South Sudanese commercial banks, consistent with Ozili's (2022) view of deposit growth as a key indicator of trust in fragile banking systems. Mobile banking transactions averaged SSP 161 million, with wide variation (min SSP 11,225; max SSP 2.91 billion) indicating uneven technological diffusion consistent with Kordit (2022) finding of fragmented mobile banking adoption in South Sudan, and with Innovation Diffusion Theory's prediction that adoption varies with organizational readiness and environmental

conditions. Internet banking transfers averaged SSP 10.5 billion (SD SSP 24.2 billion; range SSP 698,432 to SSP 181.3 billion), suggesting that only a few banks had well-established internet banking infrastructure capable of processing high transaction volumes, consistent with Wol (2019) and Tadesse and Abera (2022) on infrastructural and readiness barriers in developing economies. ATM transactions averaged SSP 53.9 million (SD SSP 127 million; range SSP 3,742 to SSP 971.3 million), reflecting uneven ATM deployment consistent with Ladu (2021) and Alhassan and Asamoah (2022) on infrastructure-dependent ATM performance. FinTech-integrated customers averaged 190,000 (SD 478,000; range 100 to 4,133,061), indicating that FinTech adoption remains at an early and uneven stage, consistent with Laddu and Tongun (2022) on infrastructural and regulatory barriers to FinTech penetration, and with Transaction Cost Innovation Theory's expectation of gradual, efficiency-driven technology adoption.

Diagnostic Tests

All variables were log-transformed prior to diagnostic testing and estimation.

Normality

Table 3: Jarque-Bera Normality Test

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	Prob > chi2
Residuals	117	0.0000	0.0000	0.0000

Source: Secondary Data (2019–2025)

The Jarque-Bera test rejected the null hypothesis of normally distributed residuals (p = 0.0000), consistent with the wide value ranges observed in the descriptive statistics. Panel regression remained appropriate, however, since large panel datasets are generally less sensitive to normality violations given the asymptotic properties of panel estimators, particularly with robust standard errors (Gujarati & Porter, 2009; Baltagi, 2021).

Multicollinearity

Table 4: Variance Inflation Factors

Variable	VIF	1/VIF
Internet Banking (lVOT)	4.86	0.2058
Mobile Banking (lVMBT)	0.92	1.0870
ATM & Card (lVATM)	0.54	1.8519
FinTech Integration (lCFint)	0.49	2.0408
Mean VIF	1.7025	

Source: Secondary Data (2019–2025)

All VIF values fell well below the threshold of 10 (mean VIF = 1.70), indicating the explanatory

variables were sufficiently independent for reliable regression estimation (Gujarati & Porter, 2009; Hair et al., 2019).

Heteroskedasticity

Table 5: Heteroskedasticity Test

Test	Chi-square	Prob > chi2	Decision
Modified Wald Test	6.3e+05	0.0000	Reject H0

Source: Secondary Data (2019–2025)

The Modified Wald test rejected the null hypothesis of homoskedasticity (p = 0.0000), indicating unequal error variance across banks, expected given the structural and operational heterogeneity among South Sudanese banks (Baltagi, 2021). Robust standard errors were applied to correct for this in the final regression (Greene, 2020).

Autocorrelation

Table 6: Wooldridge Autocorrelation Test

Test	F-statistic	Prob > F	Decision
Wooldridge Test for Autocorrelation	66.244	0.0000	Reject H0

Source: Secondary Data (2019–2025)

The Wooldridge test indicated the presence of first-order autocorrelation (p = 0.0000), reflecting the persistence of banking activity (deposit growth, transaction volumes) over time — a typical feature of financial panel data (Baltagi, 2021). Robust standard errors were again applied to correct for this.

Stationarity

Table 7: Fisher-Type Panel Unit Root Test (First Differences)

Variable	Inverse Chi-square (P)	Inverse Normal (Z)	Modified Inv. Chi-square (Pm)	p-value	Conclusion
D.lCD	89.3775	-5.0618	6.7155	0.0000	Stationary
D.lCFint	263.0979	-8.5259	27.7822	0.0000	Stationary
D.lVOT	92.0489	-5.1319	7.0395	0.0000	Stationary
D.lVMBT	151.0563	-6.6393	14.1952	0.0000	Stationary
D.lVATM	111.0832	-5.7169	9.3477	0.0000	Stationary

Source: Secondary Data (2019–2025)

All variables were stationary after first differencing (p = 0.0000 in all cases), permitting reliable panel regression estimation while minimizing the risk of spurious regression (Baltagi, 2021).

Linearity / Model Specification

Table 8: Link Test Results

Variable	Coefficient	Std. Error	t-value	p-value
_hat	0.9717	0.0212	45.89	0.000
_hatsq	0.0327	0.0177	1.85	0.067
Constant	-0.0073	0.0133	-0.55	0.582

Source: Secondary Data (2019–2025)

The squared predicted value (_hatsq) was statistically insignificant (p = 0.067 > 0.05), indicating no major specification error and confirming that the model's functional form was appropriately linear, with the log-transformation supporting model stability.

Hausman Specification Test

Table 9: Hausman Specification Test

Test	Chi-square	df	Prob > chi2	Decision
Hausman Test	13.32	4	0.0098	Reject H0

Source: Secondary Data (2019–2025)

The Hausman test rejected the null hypothesis (p = 0.0098), confirming that the fixed effects model was the more consistent and appropriate estimator, implying that unobserved bank-specific characteristics managerial practice, institutional structure, customer trust, technological capability significantly shaped the digital innovation–deposit growth relationship.

Correlation Analysis

Table 10: Pearson Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)
(1) Customer deposits	1.000				
(2) Online transfers	0.822 (0.000)	1.000			
(3) Mobile transfers	0.886 (0.000)	0.513 (0.000)	1.000		
(4) ATM transactions	0.793 (0.000)	0.536 (0.000)	0.407 (0.000)	1.000	
(5) FinTech Integration	0.733 (0.000)	0.581 (0.000)	0.403 (0.000)	0.326 (0.000)	1.000

Source: Secondary Data (2019–2025)

All four digital innovation indicators were positively and significantly correlated with customer deposits. Mobile transfers recorded the strongest association (r = 0.886, p = 0.000), followed by

online transfers (r = 0.822, p = 0.000), ATM transactions (r = 0.793, p = 0.000), and FinTech integration (r = 0.733, p = 0.000) — consistent with Donou-Adonsou (2021) on mobile banking's role in financial inclusion, Tadesse and Abera (2022) on internet banking's service-delivery benefits, Alhassan and Asamoah (2022) on ATM-driven banking convenience, and Arner et al. (2020) and Ozili (2022) on FinTech's contribution to financial service accessibility.

Fixed Effects Regression Results

Table 11: Fixed Effects Regression Results (Dependent Variable: Customer Deposit Growth)

Variable	Coef.	Robust St.Err.	t-value	p-value	[95 percent CI]	Sig.
Online Transfers	0.056	0.006	9.29	0.000	[0.043, 0.069]	***
Mobile Banking	0.826	0.166	4.96	0.000	[0.473, 1.179]	***
ATM & Card	-0.025	0.048	-0.52	0.612	[-0.126, 0.077]	
FinTech Integration	0.230	0.190	1.21	0.242	[-0.172, 0.632]	
Constant	-0.060	0.058	-1.04	0.313	[-0.182, 0.062]	

*Mean dependent var = 0.602; SD dependent var = 0.628; R-squared = 0.870; Number of obs = 100; F-test = 645.92; Prob > F = 0.0000; AIC = -205.621; BIC = -197.806. *** p<0.01. Source: Secondary Data (2019–2025)*

The overall model was statistically significant (F = 645.92, p = 0.0000), with the four digital innovation variables jointly explaining approximately 87.0 percent of the variation in customer deposit growth (R^2 = 0.870) showing the substantial explanatory power of digital innovation for bank performance in South Sudan.

Mobile Banking and Bank Performance

Mobile banking had the strongest positive and statistically significant effect on customer deposit growth (β = 0.826, p = 0.000), leading to rejection of H01. Holding other factors constant, a one-unit increase in mobile banking transaction activity raised customer deposit growth by 0.826 units, which was the largest effect of any digital innovation variable in the model. This finding is consistent with Donou-Adonsou (2021) on mobile banking's role in financial inclusion and customer engagement in developing economies, and supports Innovation Diffusion Theory's premise that perceived benefit and compatibility drive adoption and, ultimately, performance gains. The unusually large effect size further suggests that, in infrastructure-constrained economies such as South Sudan, mobile banking functions less as a complement to branch banking and more as a substitute for it, hence extending Innovation Diffusion Theory to suggest that innovation adoption in fragile economies is shaped as much by infrastructural necessity as by technological sophistication.

Internet Banking and Bank Performance

Internet banking had a positive and statistically significant effect on customer deposit growth (β = 0.056, p = 0.000), leading to rejection of H02. A one-unit increase in online transfer activity raised deposit growth by 0.056 units, holding other factors constant. This finding aligns with Tadesse and Abera (2022) on internet banking's positive influence through improved service delivery and operational efficiency, and supports the view that banks offering efficient digital transaction channels build stronger customer relationships and trust, consistent with the Technology Acceptance Model's emphasis on perceived usefulness and ease of use as drivers of continued adoption.

ATM and Card Services and Bank Performance

ATM and card services recorded a negative and statistically insignificant effect on customer deposit growth (β = -0.025, p = 0.612), and the study failed to reject H03. Despite a strong positive bivariate correlation with deposits (r = 0.793), ATM and card service intensity did not independently predict deposit growth once the other digital innovation variables were controlled for. This may reflect infrastructural limitations such as unreliable electricity, limited network coverage, machine downtime and the possibility that ATM transactions are more closely associated with withdrawals than with deposits. The finding partially contrasts with Alhassan and Asamoah (2022), who found ATM services positively contributed to banking efficiency and satisfaction in more developed banking environments, underscoring that ATM service benefits documented elsewhere may not transfer automatically to infrastructure-constrained, fragile economies.

FinTech Integration and Bank Performance

FinTech integration had a positive but statistically insignificant effect on customer deposit growth (β = 0.230, p = 0.242), and the study failed to reject H04. While the positive coefficient suggests FinTech-enabled services and customer deposit growth move in the same direction, the relationship was not strong enough to be statistically significant at the 5 percent level during the study period. This is consistent with Laddu and Tongun (2022), who found FinTech integration in South Sudan continues to face infrastructural, regulatory, and technological barriers despite its potential. The result suggests FinTech adoption in South Sudan's banking sector remains at an early developmental stage, with measurable performance effects likely to emerge as digital ecosystems, regulatory frameworks, and technological infrastructure mature.

Conclusion

This study examined the effect of digital innovations including mobile banking, internet banking, ATM and card services, and FinTech integration on the performance of commercial banks in South Sudan, measured through customer deposit growth, using a seven-year panel dataset

(2019–2025) and a Fixed Effects regression model. The findings demonstrate that mobile banking and internet banking are significant, positive drivers of customer deposit growth, with mobile banking exerting by far the largest effect. This reflects its role as a substitute for limited physical banking infrastructure in a fragile, post-conflict economy. Internet banking similarly improves deposit mobilization by enhancing transaction convenience, accessibility, and customer trust. In contrast, ATM and card services and FinTech integration, while positively correlated with deposits at the bivariate level, did not exert statistically significant independent effects once other digital channels were accounted for, reflecting persistent infrastructural, regulatory, and technological-readiness constraints specific to the South Sudanese banking environment.

These results affirm that digital innovation can be a powerful lever for deposit mobilization and institutional trust-building in fragile economies, but that its effectiveness is not uniform across channels and it depends heavily on the supporting infrastructural and regulatory environment. The study therefore concludes that mobile and internet banking currently offer the most reliable performance returns for South Sudanese commercial banks, while ATM, card, and FinTech channels retain substantial untapped potential that remains constrained by structural barriers rather than by any inherent limitation of the technologies themselves.

Recommendations

Mobile Banking

Commercial banks in South Sudan should prioritize investment in mobile banking technologies and infrastructure, expanding accessibility, improving transaction reliability, and developing user-friendly platforms that serve both urban and rural populations. Partnerships with telecommunications companies can extend network coverage and reduce transaction costs, while the Bank of South Sudan should support policies that encourage digital financial inclusion and mobile financial service innovation.

Internet Banking

Banks should strengthen internet banking systems through investment in secure, reliable, and accessible online platforms, improved cybersecurity, and sustained customer education to build digital literacy and confidence in online transactions. Government and regulatory agencies should invest in improving national internet infrastructure and connectivity to facilitate broader adoption.

ATM and Card Services

Banks should improve the reliability and density of ATM networks, reduce machine downtime, and ensure consistent cash availability, alongside stronger security features for card payment systems to build customer confidence in electronic transactions. Government and infrastructure providers should address underlying constraints such as unreliable electricity supply and

telecommunications gaps that limit ATM effectiveness.

FinTech Integration

Although FinTech integration's effect was not statistically significant during the study period, its positive coefficient signals meaningful long-term potential. Banks should pursue strategic partnerships with FinTech firms, invest in digital innovation capabilities, and adopt emerging financial technologies that enhance service efficiency. The Bank of South Sudan should develop supportive regulatory frameworks for FinTech innovation, complemented by sustained investment in digital infrastructure, technological readiness, and digital literacy programmes.

Areas for Further Research

Future research should broaden bank performance measurement beyond customer deposit growth to include additional financial and non-financial indicators, providing a more comprehensive view of how digital innovation affects different dimensions of banking performance. Studies should also incorporate additional controls such as bank size, age, liquidity, capital adequacy, and macroeconomic conditions and examine the moderating or mediating roles of regulatory quality, technological infrastructure, digital literacy, cybersecurity readiness, and customer trust. Comparative studies across other fragile or post-conflict East African economies, and longitudinal research extending beyond the current study period, would further clarify whether these findings are context-specific to South Sudan or generalizable to similarly constrained financial environments.

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