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LIQUIDITY MANAGEMENT CONSTRAINTS AND OPERATIONAL EFFICIENCY IN ISLAMIC BANKING SYSTEMS IN SUB-SAHARA AFRICA

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Abstract

This study examines whether liquidity management enhances or constrains the operational efficiency of Islamic banks operating in SSA, where Sharīʿah-compliant financial infrastructure remains underdeveloped. Using panel data from 35 fully fledged Islamic banks over the period 2010–2024, the study employs a bias-corrected two-stage Data Envelopment Analysis (DEA) framework with Simar–Wilson bootstrap procedures, followed by fixed-effects regression to ensure consistent inference. The findings reveal that, despite maintaining relatively high liquidity buffers, Islamic banks in SSA operate significantly below the efficiency frontier, with average bias-corrected efficiency levels of 31.8%. Contrary to conventional banking theory, liquidity exhibits only a weak and marginal relationship with efficiency. This result reflects structural features of SSA Islamic financial systems, including shallow sukuk markets, limited Islamic interbank activity, and the absence of effective Sharīʿah-compliant lender-of-last-resort facilities, which collectively constrain the productive deployment of liquidity. By conceptualising liquidity as a binding monetary constraint rather than a discretionary management tool, this study offers a novel contribution to Islamic banking and monetary economics, particularly in the context of institutionally incomplete markets. The results further show that asset quality and institutional maturity play a more decisive role in shaping efficiency outcomes once liquidity constraints bind. The findings highlight that improving efficiency in SSA Islamic banking systems requires system-level reforms, underscoring the need for Islamic monetary authorities to prioritise the development of Sharīʿah-compliant liquidity infrastructure, including active sukuk markets, Islamic interbank facilities, and credible lender-of-last-resort mechanisms.

Keywords: *Islamic Banking, Liquidity Management, Operational Efficiency, Financial Soundness*

INTRODUCTION

Islamic banking has become an integral part of the global financial architecture, based on Sharīʿah tenets that forbid interest (ribā), excessive uncertainty (gharar), and gambling or speculation (maysir) (Mohamad et al., 2022; Svoboda, 2024; Ullah et al., 2023), and instead emphasize financing based on assets and sharia-compliant risk-sharing patterns of financial intermediation. In recent decades, the growth of the broader Islamic financial sector has been steady, fueled by a rising demand for ethical finance, financial inclusion, and resilience-based financial intermediation (Dawood et al., 2022; Tahir & Ibrahim, 2020). Of these, Islamic banking is currently the most prominent part of the global Islamic financial sector, comprising the largest share of overall global Islamic financial assets. At the same time, however, the global growth of Islamic banking is a geographically imbalanced phenomenon. While jointly comprising the overwhelming bulk of global Islamic banking assets, the Middle East and North Africa (MENA) and Southeast Asia regions contrast starkly with Sub-Saharan Africa (I. Kateb et al., 2023; Mateev et al., 2021; Mateev & Nasr, 2023), which currently remains a marginal part of global Islamic finance, despite its huge and continuously expanding Muslim population.

Despite the rapid global expansion of Islamic finance, its geographical distribution remains highly uneven. The Middle East and North Africa (MENA) region dominates the

industry, accounting for approximately 77.4% of global Islamic financial assets, supported by well-developed regulatory frameworks and deep financial markets (IFSB, 2025). In contrast, SSA remains a marginal participant, contributing only about 1.7% of global Islamic banking assets, despite hosting over 250 million Muslims and a rapidly growing population. At the institutional level, the region operates with only 51 fully fledged Islamic banks across 49 countries, compared to a significantly larger conventional banking presence. This stark disparity highlights not only the limited scale of Islamic banking in SSA but also underscores the structural and institutional constraints that differentiate the region from more mature Islamic financial systems.

Islamic banks in SSA operate within structurally constrained financial systems characterized by underdeveloped Sharīʿah-compliant liquidity infrastructure and fragmented regulatory environments. These range from dual banking systems in Kenya to evolving sukuk frameworks in Nigeria and fully Islamized systems in Sudan (Akinbowale et al., 2025; Gondwe et al., 2022). Regulatory environments vary significantly across countries, with dual banking systems in countries such as Kenya, evolving Islamic finance frameworks and sovereign sukuk initiatives in Nigeria, and fully Islamized systems in Sudan. Despite this institutional diversity, a common feature across the region is the absence of integrated Islamic liquidity management frameworks. This is reflected in shallow and sporadic sukuk issuance, illiquid secondary markets, limited Islamic interbank activity, and the absence of effective Sharīʿah-compliant lender-of-last-resort facilities (F. E. Kateb et al., 2025; Mohd Zain et al., 2021). These constraints are mutually reinforcing, limiting collateralized liquidity operations, restricting short-term liquidity redistribution, and weakening systemic liquidity support. Consequently, Islamic banks are compelled to maintain precautionary liquidity buffers, not as an optimization strategy, but as a response to institutional rigidities that hinder the efficient transformation of financial resources into productive financing.

This structural configuration fundamentally differentiates Islamic banking in SSA from conventional banking systems and from Islamic banking systems in more developed regions. While conventional banks rely on deep interbank markets, government securities, and active central bank liquidity operations, Islamic banks depend on a narrower set of Sharīʿah-compliant instruments—such as *sukuk, commodity murābaḥah, wakālah placements*, and profit-sharing interbank arrangements—whose effectiveness is contingent upon market depth and institutional support (Al-Deek, 2025; Çakmak & Sunal, 2024). In SSA, however, these supporting markets remain insufficiently developed, limiting the ability of banks to actively deploy liquidity. Consequently, liquidity may not function as a performance-enhancing resource but rather as a binding operational constraint, raising a critical question as to whether conventional liquidity–efficiency relationships hold in structurally incomplete Islamic financial systems.

The fact that Islamic banks in SSA continue to exhibit excess holdings of liquidity raises an important question in terms of whether the relationship between liquidity management and efficiency is applicable in this particular context. The available evidence in this regard is such that Islamic banks in SSA have been shown to have strong liquidity conditions (Al-Deek, 2025), but have been less efficient in terms of profitability relative to their conventional counterparts in more developed Islamic markets (Abdallah & Bahloul, 2024; Javid et al., 2024). The fact that strong liquidity conditions are accompanied by inefficient performance in this way raises important issues in terms of whether conventional views of the relationship between liquidity conditions and efficiency are applicable in this

particular context, in which the Islamic financial markets are still incomplete in terms of their infrastructure.

Existing literature on Islamic banking has extensively examined liquidity management and operational efficiency, but largely within the context of relatively developed financial systems. Studies focusing on the Middle East and Southeast Asia typically conceptualize liquidity as a balance-sheet management variable or a risk indicator, operating under the implicit assumption of well-functioning Sharīʿah-compliant financial infrastructures, including active sukuk markets and Islamic interbank systems (Ferdous & Miah, 2025; Hacini et al., 2021; Khalaf & Awad, 2024). Within such environments, liquidity is generally expected to enhance financial intermediation and improve efficiency outcomes. At the same time, a substantial body of literature employs Data Envelopment Analysis (DEA) to evaluate operational efficiency in Islamic banking, highlighting its suitability for capturing multi-input and multi-output banking processes (Mai et al., 2023; Uddin et al., 2025). However, most of these studies treat liquidity as a control variable rather than a central explanatory factor and assume the presence of deep and functional Islamic financial markets.

This conventional perspective does not adequately reflect the realities of SSA, where Islamic financial systems remain structurally underdeveloped. Empirical evidence suggests that Islamic banks in SSA maintain relatively high liquidity buffers while simultaneously exhibiting low levels of operational efficiency (Al-Deek, 2025; Javid et al., 2024; Safdar et al., 2024). This divergence reflects institutional and market constraints, including shallow sukuk markets, limited Islamic interbank activity, and the absence of Sharīʿah-compliant lender-of-last-resort facilities (Akinbowale et al., 2025; Gondwe et al., 2022). Despite these conditions, empirical studies explicitly examining the impact of liquidity management constraints on efficiency in SSA remain scarce, as most existing research focuses on more mature Islamic financial systems (Khalaf & Awad, 2024; Sherif & Hussnain, 2017). This highlights a critical gap in the literature regarding how liquidity operates in structurally incomplete financial environments.

In contrast to the prevailing view of liquidity as a discretionary management tool, this study adopts an alternative conceptual perspective by treating liquidity as a binding structural constraint. In environments characterized by underdeveloped Sharīʿah-compliant financial markets, excess liquidity reflects precautionary behavior rather than optimal balance-sheet management (Akram & Hushmat, 2024; Al-Deek, 2025). The absence of deep sukuk markets, limited interbank liquidity mechanisms, and weak institutional support restricts the ability of Islamic banks to deploy liquid assets into productive financing activities (Akinbowale et al., 2025; Çakmak & Sunal, 2024). As a result, liquidity constrains rather than enhances operational efficiency, fundamentally altering the conventional liquidity–efficiency relationship. This reconceptualization is particularly relevant in SSA, where institutional and market frictions transform liquidity from a performance-enhancing resource into a binding operational limitation.

Despite the emergence of literature assessing liquidity risk(Chowdhury et al., 2023; Mustafa, 2020; Safdar et al., 2024; Shonhadji, 2023; Yahaya et al., 2022), financial stability (El Khatib & Ferreira Savoia, 2024; Kuria et al., 2024; Pusparini et al., 2023), and operational efficiency in Islamic banking, most of the literature available to date regards liquidity as either a balance sheet management variable or risk indicator in more mature Islamic financial structures, especially in MENA regions and Southeast Asia. Such literature is based upon implicit assumptions of the presence of functional Sharīʿah-compliant money markets, liquid sukuk markets, and functional Islamic monetary instruments in such regions (Ferdous &

Miah, 2025; Hacini et al., 2021). However, little work appears to have been conducted in contexts in which liquidity is itself a binding structural constraint rather than simply a managerial option (Akram & Hushmat, 2024; Al-Deek, 2025).

Despite a substantial body of literature examining the relationship between liquidity management and operational efficiency in Islamic banking, existing studies are largely grounded in institutional contexts characterized by relatively developed Sharīʿah-compliant financial infrastructures, particularly in the Middle East and Southeast Asia. Within these settings, liquidity is typically modelled as a discretionary balance-sheet variable or risk management tool, implicitly assuming the presence of deep sukuk markets, active Islamic interbank systems, and functional central bank liquidity facilities. However, this assumption does not hold in structurally incomplete financial systems such as those found in SSA. In such environments, liquidity is not merely a managerial choice but may instead operate as a binding structural constraint imposed by institutional and market deficiencies. Yet, this conceptualization remains largely absent from the empirical literature. Accordingly, this study departs from conventional approaches by explicitly re-framing liquidity as a system-level monetary constraint rather than a bank-level optimization variable, thereby addressing a critical gap in the literature and extending the analysis of Islamic banking efficiency to contexts characterized by institutional fragility and incomplete financial markets.

This study addresses a definite gap in existing literature. It examines how liquidity management constraints influence the operational efficiency of Islamic banks in SSA. It queries whether traditional liquidity measures can help increase efficiency or simply capture rigidities arising out of underdeveloped Sharīʿah-compliant markets and monetary systems. To analyze this, this study employs a bias-corrected Two-Stage DEA approach to estimate operational efficiency for 35 fully fledged Islamic banks in SSA during 2010-2024, and then fixed-effects panel regression analysis to examine how efficiency is influenced by liquidity. By casting the management of liquidity in terms of the systemic monetary constraint and not in terms of performance, this study contributes three points in the field of Islamic banking and monetary economics. Firstly, it offers cross-country findings in the SSAn context, which remains underrepresented in empirical Islamic banking literature. Secondly, it interprets the relationship between liquidity and efficiency in the framework of incomplete Islamic financial markets, thus expanding the theories of efficiency and stability. Thirdly, it offers findings for Islamic monetary authorities and regulators in developing Sharīʿah-compliant instruments of liquidity, fostering active markets for sukūk, and establishing effective lender-of-last-resort facilities.

METHODOLOGY

Data and Sample

The study analyzed 35 Islamic banks in SSA from 2010 to 2024, resulting in 525 observations. It focused on banks in countries with established Islamic banking frameworks, excluding banking windows to maintain purely Sharīʿah-compliant practices. Data were sourced from Islamic banks' annual reports, IMF indicators, and other databases, covering a period that reflects regulatory changes and macroeconomic stress. The goal was to examine liquidity constraints through operational efficiency, using Data Envelopment Analysis (DEA) in a two-stage empirical framework. The first stage estimated operational efficiency, while the second regressed efficiency scores on liquidity indicators and controls via a fixed-effects model (Simar & Wilson, 2020). This approach addressed biases in traditional DEA

scores and accounted for market and regulatory constraints impacting liquidity in Islamic banking in SSA (Samad, 2024).

Selection of DEA Inputs and Outputs

To align with this intermediation view of the banking industry and best practice within the Islamic banking efficiency literature, Islamic banks were represented as decision-making entities that turn operating resources into income-generating activities (Samad, 2024; Simar & Wilson, 2020). Because the study mainly examined operational efficiency under liquidity constraints, we used input and output variables (banking cost structures and productive outcomes) over balance-sheet scale.

Table 1

DEA Input and Output Variables Used in the Efficiency Estimation

Variable name	Description
Input variables:	
Administrative Expenses	Total Administrative expense of each bank per year
Non-Interest expenses	Non-Interest expense of each bank per year
Personnel Expenses	Total Personnel Expenses to each bank per year
Output variables:	
Net Operating Income	The total income from core banking operations including fees & Commissions of each bank per year.
Net Fees and Commission	Net Fees and Commission of each bank per year
Total other income	Total other income including foreign exchange income, Gain on investment revaluation, Rental income, Dividend income, and Other non-operating Shariah-compliant income of each bank per year

On the input side, personnel, administrative, and other non-interest expenses are used to capture the operational costs of delivering Sharīʿah-compliant financial services, reflecting managerial efficiency and resource utilisation in constrained environments (Mai et al., 2023; Rusydiana & As-Salafiyah, 2021). On the output side, net operating income, fees and commission income, and other Sharīʿah-compliant income capture banks' productive performance. Other income reflects non-financing revenue streams—such as investment and foreign exchange income—which are particularly relevant where liquidity constraints limit traditional financing activities (Samad, 2024). These outputs align with Islamic banking principles by focusing on asset-based and profit-sharing income while excluding interest-based measures (Samad, 2024). The selected inputs and outputs are consistent with prior efficiency studies, ensuring comparability while aligning with the study's conceptualisation of efficiency as an outcome shaped by systemic frictions rather than scale or discretionary balance-sheet expansion (Mai et al., 2023; Simar & Wilson, 2020).

Stage One: Measurement of Operational Efficiency

Operational efficiency was estimated using an output-oriented DEA model under Variable Returns to Scale (VRS) (Simar & Wilson, 2020), reflecting heterogeneity in bank size and operating environments across SSA. To account for substantial heterogeneity and variation across banks and over time, as evidenced by the wide dispersion and non-normal distribution of key variables, the analysis adopts a VRS specification. This approach accommodates differences in operational scale and mitigates distortions arising from cross-sectional variability. In addition, the Simar–Wilson bootstrap procedure corrects for bias in

DEA efficiency estimates and improves robustness against extreme observations and sampling variability (Simar & Wilson, 2007). An output-oriented specification is appropriate in the SSA context, where Islamic banks face structural constraints in expanding inputs due to limited access to Sharīʿah-compliant funding and liquidity instruments. Consequently, banks are more likely to focus on maximising income generation from existing resources rather than adjusting input levels, making output orientation more consistent with the operational realities of constrained Islamic financial systems. Islamic banks were modelled as financial intermediaries that transformed operating costs into income-generating activities (Rusydiana & As-Salafiyah, 2021). For each bank i in year t, the VRS efficiency score was obtained by solving the following linear programming problem:

$$\max_{\theta,\lambda} \ \theta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subject to:

$$\sum_{j=1}^{N} \lambda_j \, y_{rj} \geq \theta y_{ri}, r = 1, \ldots, R$$

$$\sum_{j=1}^{N} \lambda_j \, x_{kj} \leq x_{ki}, k = 1, \ldots, K$$

$$\sum_{j=1}^{N} \lambda_j = 1, \lambda_j \geq 0$$

where y_r - denotes output variables and x_k - denotes input variables. Outputs included net operating income, fees and commissions, and other Sharīʿah-compliant income, while inputs comprised administrative expenses, personnel expenses, and non-interest expenses (Mai et al., 2023). The efficiency score θmeasured the proportional expansion in outputs achievable given the observed input bundle.

To address the well-documented upward bias in conventional DEA estimators, the study applied the Simar–Wilson (2007) bootstrap procedure (Simar & Wilson, 2007). Bias-corrected efficiency scores were computed as:

$$\hat{\theta}_{it}^{BC} = \hat{\theta}_{it} - \widehat{\text{Bias}}(\hat{\theta}_{it}) \quad (2)$$

where $\hat{\theta}_{it}$ - is the original DEA efficiency estimate and $\widehat{\text{Bias}}(\hat{\theta}_{it})$ - is the bootstrap-estimated bias. These bias-corrected VRS efficiency scores constituted the dependent variable in the second-stage analysis.

Stage Two: Liquidity–Efficiency Regression Model

In the second stage, the study examined whether liquidity management constraints influenced operational efficiency using a two-way fixed-effects panel regression model. Liquidity management was conceptualized as a structural constraint rather than a discretionary performance driver; other financial soundness indicators are included solely to isolate this constraint within the efficiency framework (Simar & Wilson, 2020). The baseline fixed-effects specification used to examine the relationship between liquidity management constraints and operational efficiency is given by:

$$\theta_{it} = \alpha + \beta_1 LIQ_{it} + \beta_2 LDR_{it} + \delta Z_{it} + \mu_i + \lambda_t + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where θ_{it} - denotes the bias-corrected DEA efficiency score of bank $i$at time t, LIQ_{it} - is the liquidity ratio, LDR_{it} - is the loan-to-deposit ratio, Z_{it} - is a vector of control variables including asset quality, earnings quality, bank size, and bank age, μ_i - captures unobserved bank-specific effects, λ_t - controls for time effects, and ε_{it} - is the idiosyncratic error term.

In addition to the core explanatory and moderating variables, the empirical model included a set of bank-level control variables to account for heterogeneity in balance-sheet composition and income structure. Specifically, asset quality and earnings quality were included as statistical controls to partial out variations in financing performance and income volatility that may influence efficiency scores but are not central to the theoretical framework of the study (Safdar et al., 2024). Their inclusion ensures that the estimated effects of liquidity management reflect underdeveloped liquidity infrastructure rather than differences in asset performance or earnings composition.

Estimation and Diagnostic Procedures

All the regressions were estimated using fixed-effects estimators with robust standard errors to account for heteroskedasticity and within-bank serial correlation. The fixed-effects method was chosen based on formal model selection tests and theoretical considerations regarding unobserved heterogeneity in Islamic banking operations across jurisdictions. Robustness tests also included alternative liquidity proxies and model re-estimation under different efficiency measures. Qualitatively, the results remained consistent, indicating that they were not dependent on the choice of liquidity indicator or the specification of the estimation parameters.

The study added to the existing research a systematic methodology in which bias-corrected DEA efficiency estimation was combined with panel fixed-effects regression to understand the efficiency considerations related to liquidity management constraints in Islamic banking systems. In contrast to previous studies that utilized traditional DEA or single-stage models in their analysis, this approach controlled for statistical bias, unobserved heterogeneity, and explicitly acknowledged structural liquidity constraints in underdeveloped Islamic finance markets. Therefore, the methodology provided a more precise assessment of how liquidity conditions influence the operational efficiency of SSA Islamic banking systems.

RESULTS & DISCUSSION

Results

Table 2 reports summary statistics for the input and output variables used in the DEA estimation across 525 bank–year observations for Islamic banks operating in SSA over the period 2010–2024.

Table 2
Descriptive statistics of the inputs and outputs.

Statistic	Mean	Median	Max	Min	Std. Dev.	Skew ness	Kurtosis
Non-Interest Expenses	13250.75	4441.75	522356.	0	36743.8	8.644	98.211
Total Operating expenses	18874.5	11046.6	794811	5.73	43156.8	12.66	210.35

Statistic	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
Net Impairment charges on financing and advances	2698.1	1000.98	60773.9	0	5532.53	5.602	44.266
Non-Interest Income	16566.2	8961.96	467314	0	29639.5	8.102	107.916
Net Fees Commission	6377.4	3017.5	141884	0	11279	5.388	48.554
Total Other Income	11882.5	4527.98	279319	0	21772.3	5.702	54.725

From Table 2. Non-interest expenses averaged 13,250.75 (median 4,441.75), while total operating expenses averaged 18,874.5 (median 11,046.6), both exhibiting high maximum values and large standard deviations. Net impairment charges averaged 2,698.1. On the output side, non-interest income averaged 16,566.2, net fees and commissions 6,377.4, and total other income 11,882.5. Minimum values across variables were near zero, with substantial dispersion. All variables show positive skewness (5.388–12.66) and high kurtosis (44.266–210.35), indicating non-normal, heavy-tailed distributions.

These distributional characteristics provide the basis for further descriptive analysis. Descriptive statistics of the study variables, based on 525 bank–year observations from 35 fully-fledged Islamic banks operating in SSA during 2010–2024, are presented in Table 3.

Table 3
Descriptive Statistics of Study Variables

Variable	Mean	Std. Dev.	Min	Max	Between SD	Within SD
Bias-corrected VRS Efficiency	0.318	0.191	0.037	0.782	0.136	0.136
Liquidity Ratio	28.454	11.183	4.236	57.313	7.479	8.403
Financing-to-Deposit (LDR)	8.900	12.708	0.013	86.793	11.21	6.259
Net Profit Margin	28.117	20.564	0.022	97.919	16.72	12.28
Impaired Financing / Equity	56.445	35.216	0.602	280.050	25.224	24.879
Log of Deposits (Bank Size)	11.484	2.328	0.154	16.470	2.187	0.873
Bank Age (years)	20.139	13.705	0.00	65.00	13.197	4.282

The average bias-corrected VRS efficiency score is 0.318 (SD = 0.191), with values ranging from 0.037 to 0.782. The mean liquidity ratio is 28.454 (SD = 11.183), while the financing-to-deposit ratio averages 8.900 (SD = 12.708), both showing wide ranges. Net profit margin has a mean of 28.117 (SD = 20.564), and impaired financing to equity averages 56.445 (SD = 35.216). Bank size, measured as the log of deposits, has a mean of 11.484 (SD = 2.328), while bank age averages 20.139 years (SD = 13.705). Across variables, dispersion is evident in both between and within-standard deviations, indicating variability across banks and over time.

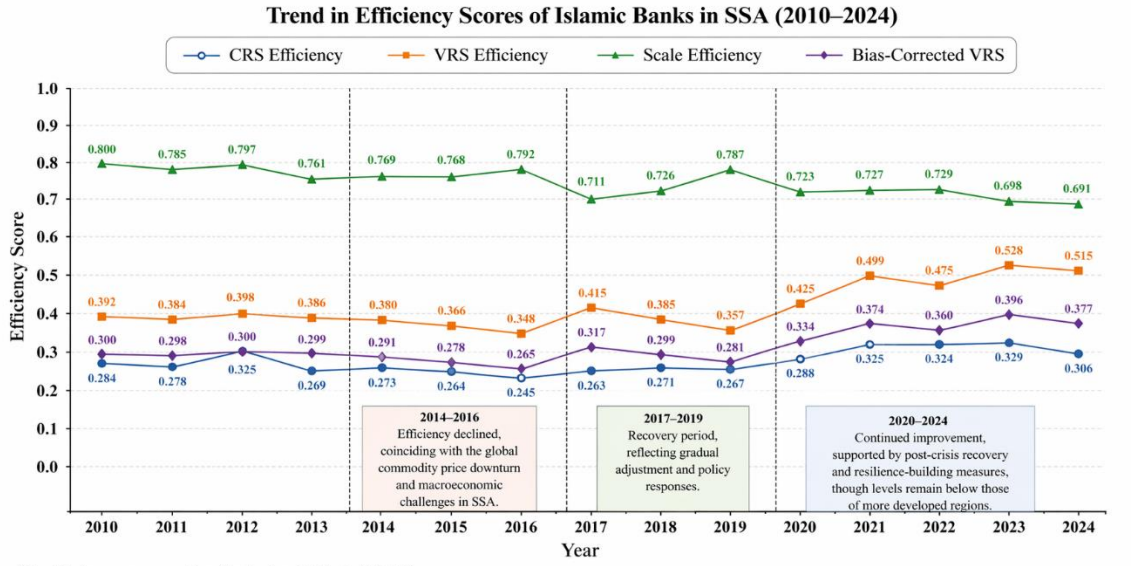
The descriptive statistics in Table 3 highlight substantial variability across banks and over time. Building on these characteristics, operational efficiency was estimated using an output-oriented DEA model under both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) assumptions. Table 4 reports the average efficiency scores for Islamic banks in SSA over the period 2010–2024.

Table 4
Summary Efficiency Scores (2010–2024)

Measure	Mean
CRS Technical Efficiency	0.287
VRS Technical Efficiency	0.417
Scale Efficiency	0.751

To complement these summary statistics, Figure 2 illustrates the temporal evolution of CRS, VRS, scale, and bias-corrected efficiency scores.

Figure 2
Trends in efficiency Scores of Islamic banks in SSA (2010-2024)



Note: Efficiency scores range from 0 to 1, where 1 indicates full efficiency.
Source: Authors' computation using DEA (Simar–Wilson two-stage bootstrap).

The results show that VRS efficiency (0.417) exceeds CRS efficiency (0.287), with an average scale efficiency of 0.751. A consistent gap between CRS and VRS efficiency is observed over time. Efficiency remains relatively stable from 2010 to 2013, declines between 2014 and 2016 across all measures, and then gradually recovers from 2017 onwards, with more pronounced improvements after 2020.

The time-series patterns in Figure 2 highlight persistent differences between CRS and VRS efficiency. To complement these trends, Table 5 presents the original and bias-corrected VRS efficiency scores, providing a more robust measure of bank-level performance across the sample.

Table 5
Bias-Corrected VRS Efficiency Scores

Year	VRSTE	Bias Corrected VRSTE
2010	0.392	0.300
2011	0.384	0.298
2012	0.398	0.300
2013	0.386	0.299
2014	0.380	0.291

Year	VRSTE	Bias Corrected VRSTE
2015	0.366	0.278
2016	0.348	0.265
2017	0.415	0.317
2018	0.385	0.299
2019	0.357	0.281
2020	0.425	0.334
2021	0.499	0.374
2022	0.475	0.360
2023	0.528	0.396
2024	0.515	0.377
Average	**0.417**	**0.318**

Across all years, bias-corrected scores are consistently lower than the corresponding DEA estimates. The average VRSTE is 0.417, while the average bias-corrected efficiency score is 0.318. Yearly bias-corrected scores range from 0.265 (2016) to 0.396 (2023), showing variation over time with generally lower adjusted values relative to the original estimates.

The bias-corrected efficiency scores in Table 5 highlight persistent differences relative to the original DEA estimates, with notable variation across years. To further investigate the determinants of these efficiency outcomes, Table 6 reports the full two-way fixed-effects regression results corresponding directly to Equation (2):

$$\hat{\theta}_{it}^{BC} = \alpha + \beta_1 \text{Liquidity}_{it} + \gamma' \mathbf{Z}_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

While liquidity management is the focal explanatory variable, other financial soundness indicators are included as control variables to account for banks' overall financial conditions and mitigate omitted variable bias.

Table 6
Fixed-Effects Regression Results (Dependent Variable: Bias-Corrected VRS Efficiency)

Variable	Coefficient	Robust SE	p-value
Capital Adequacy	−0.00132	0.00118	0.262
Earnings Quality	−0.00087	0.00026	0.001 ***
Liquidity Management (LDR)	0.00288	0.00155	0.064 *
Asset Quality	0.00046	0.00024	0.060 *
Bank Size	−0.01298	0.00978	0.185
Bank Age	0.00963	0.00416	0.021 *
R^2	0.056		
F-statistic	2.52		0.004

Table 6 presents the fixed-effects regression results with bias-corrected VRS efficiency as the dependent variable. Liquidity management (LDR) has a positive coefficient (0.00288) and is marginally significant (p = 0.064). Earnings quality shows a negative and statistically significant effect (−0.00087, p = 0.001), while asset quality is positive and marginally significant (0.00046, p = 0.060). Bank age has a positive and significant coefficient (0.00963, p = 0.021), whereas capital adequacy (−0.00132, p = 0.262) and bank size (−0.01298, p = 0.185) are not statistically significant. The model reports an R^2 of 0.056 and an F-statistic of 2.52 (p = 0.004).

The regression results in Table 6 provide insights into the direct effects of liquidity management and other financial soundness indicators on efficiency. Building on these findings, this section evaluates whether the marginal liquidity–efficiency relationship is conditioned by institutional maturity, proxied by bank age. Interaction effects were jointly significant ($\chi^2(4) = 18.89$, $p < 0.001$), confirming that bank age moderated the financial soundness–efficiency relationship.

Table 7
Joint Test of Interaction Effects

Model	χ^2	p-value
Financial Soundness × Bank Age	18.89	0.000826

Table 7 reports the joint test of interaction effects between financial soundness indicators and bank age. The results show that the interaction effects are jointly significant ($\chi^2 = 18.89$, $p = 0.000826$), indicating that bank age moderates the relationship between financial soundness variables and bias-corrected VRS efficiency.

The joint test of interaction effects in Table 7 confirms that bank age significantly moderates the relationship between financial soundness indicators and efficiency. Building on this evidence, Table 8 reports the results of the optimal fixed-effects specification, which retains a parsimonious set of variables that jointly explain operational efficiency in Islamic banks operating in SSA. The model includes liquidity management alongside bank size, bank age, asset quality, and earnings quality, indicating that efficiency outcomes in the region are shaped by both structural constraints and bank-specific conditioning factors.

Table 8
Optimal Fixed-Effects Model

Variable	Coefficient	p-value
Earnings Quality	−0.00100	<0.05 **
Asset Quality	0.00100	<0.01 ***
Liquidity Management	0.00288	0.064 *
Bank Size	−0.01300	<0.10 *
Bank Age	0.00004	<0.05 **

Earnings quality has a negative and significant coefficient (-0.00100, $p < 0.05$), while asset quality shows a positive and highly significant effect (0.00100, $p < 0.01$). Liquidity management remains positive but marginally significant (0.00288, $p = 0.064$). Bank size has a negative and weakly significant coefficient (-0.01300, $p < 0.10$), whereas bank age is positive and statistically significant (0.00004, $p < 0.05$).

Discussions

The findings provide a nuanced understanding of the liquidity–efficiency relationship in Islamic banking systems operating within structurally constrained environments. The low average bias-corrected efficiency level (0.318) indicates that banks operate well below the efficiency frontier, reflecting persistent technical inefficiencies across SSA. This is reinforced by the gap between VRS (0.417) and CRS (0.287) efficiency, which points to managerial and structural inefficiencies rather than scale-related limitations. Such evidence aligns with studies in developing financial systems where institutional rigidities, rather than expansion dynamics, shape efficiency outcomes (Mateev et al., 2023; Sherif & Hussnain, 2017). A key contribution of the study lies in the weak and marginal role of liquidity management. Although liquidity

(LDR) shows a positive coefficient (0.00288), its marginal significance ($p = 0.064$) suggests that liquidity does not materially drive efficiency once financial soundness factors are controlled for. This finding departs from conventional evidence in MENA and Southeast Asia, where liquidity supports financial intermediation and performance. In contrast, the combination of relatively high liquidity ratios (mean ≈ 28.45%) and low financing-to-deposit ratios (mean ≈ 8.90) indicates that liquidity is largely held rather than deployed, supporting the argument that it functions as a precautionary buffer under structural constraints (Hacini et al., 2021; Safdar et al., 2024). This reframes liquidity from a discretionary management tool to a binding system-level constraint.

The temporal efficiency patterns further highlight the influence of structural and macroeconomic conditions. The observed decline in efficiency between 2014 and 2016, followed by recovery after 2017 and stronger improvements post-2020, suggests that performance dynamics are shaped by external shocks and gradual institutional adjustments rather than internal scaling processes. These cyclical movements underscore the sensitivity of efficiency to macroeconomic volatility in commodity-dependent SSA economies measures (Mateev et al., 2023; Uddin et al., 2025). More importantly, the results emphasize the central role of asset quality and institutional maturity. Asset quality exhibits a positive and highly significant effect ($\beta = 0.00100$, $p < 0.01$), while bank age remains positive and significant ($\beta = 0.00004$, $p < 0.05$) . Additionally, the significant interaction effects ($\chi^2 = 18.89$, $p < 0.001$) confirm that institutional maturity strengthens the relationship between financial soundness and efficiency. This suggests that, in constrained environments, efficiency gains are driven more by internal resource allocation and accumulated experience than by liquidity conditions (Hermuningsih & Rahmawati, 2022).

The optimal model provides further clarity by isolating the most influential determinants of efficiency. Within this specification, asset quality emerges as the strongest positive driver, reinforcing the importance of effective financing allocation under binding liquidity constraints. Liquidity management retains a positive but modest and marginally significant effect ($\beta = 0.00288$, $p = 0.064$), confirming its secondary role. In contrast, earnings quality remains negatively associated with efficiency ($\beta = -0.00100$, $p < 0.05$), suggesting that income generation may involve cost-intensive or short-term strategies that do not translate into operational efficiency. Bank size shows a weak negative effect ($\beta = -0.01300$, $p < 0.10$), while bank age continues to exert a positive influence, highlighting the role of institutional experience in mitigating structural constraints.

Collectively, the optimal model underscores that efficiency in SSA Islamic banking systems is primarily shaped by internal balance-sheet quality and institutional maturity rather than liquidity accumulation. The coexistence of high liquidity buffers, low efficiency levels, and weak liquidity effects confirms that liquidity operates as a structural constraint rather than a performance-enhancing resource. This extends the literature by introducing a system-level perspective in which liquidity is conditioned by market incompleteness and institutional deficiencies, particularly the absence of deep sukuk markets, active Islamic interbank systems, and effective Sharīʿah-compliant liquidity facilities.

CONCLUSION

This study examined the relationship between liquidity management and operational efficiency in Islamic banking systems in Sub-Saharan Africa (SSA) within the context of structurally incomplete financial markets. Using a bias-corrected two-stage Data Envelopment Analysis (DEA) framework combined with fixed-effects regression, the

findings show that Islamic banks operate significantly below the efficiency frontier despite maintaining relatively high liquidity buffers. This outcome challenges the conventional assumption that liquidity enhances efficiency and instead suggests that its role is limited in environments characterized by underdeveloped financial infrastructure. The results provide three key insights. First, liquidity functions as a binding structural constraint rather than an efficiency-enhancing resource in SSA Islamic banking systems. High liquidity holdings largely reflect precautionary behaviour driven by institutional and market limitations, rather than optimal balance-sheet management. Second, asset quality and institutional maturity emerge as more decisive determinants of operational efficiency once liquidity constraints bind, indicating that internal capacity and experience play a critical role in shaping performance outcomes. Third, the findings demonstrate that efficiency dynamics in SSA are primarily driven by structural and institutional factors, rather than scale effects or conventional liquidity management practices.

From a policy perspective, the findings highlight the need for system-level reforms to address the structural rigidities that constrain Islamic banking performance in SSA. Priority should be given to the development of active Islamic interbank markets to facilitate short-term liquidity redistribution, as well as the expansion of sovereign and corporate sukuk—particularly secondary markets—to improve the availability and tradability of Sharīʿah-compliant liquid assets. In addition, central banks should introduce dedicated Islamic liquidity management instruments, including standing facilities and Sharīʿah-compliant lender-of-last-resort mechanisms, to strengthen systemic stability. More broadly, regulatory frameworks should be adapted to reflect the operational realities of Islamic banking in structurally incomplete markets, rather than replicating conventional liquidity standards. Such reforms are essential for enabling more efficient utilisation of liquidity and enhancing overall banking performance in the region.

Finally, this study extends the literature by reframing liquidity within a structural and monetary context and by providing new empirical evidence from underexplored SSA markets. Future research may build on this work by examining dynamic liquidity adjustments and cross-country institutional variations across emerging Islamic financial systems.

REFERENCES

Abdallah, M. Ben, & Bahloul, S. (2024). The Influence of Solvency and Liquidity Ratios on Profitability of Tunisian Banks: The Moderating Effect of Asset Quality. *African Journal of Economic and Management Studies*, *16*(2), 255–270. https://doi.org/10.1108/ajems-02-2024-0136

Akinbowale, O. E., Zerihun, M. F., & Mashigo, P. (2025). Banking and financial regulation in Sub-Saharan Africa: a systematic literature review and multiple regression approach. *Journal of Financial Regulation and Compliance*, *33*(3), 359–385. https://doi.org/10.1108/jfrc-09-2024-0170

Akram, H., & Hushmat, A. (2024). Bank liquidity creation, loan concentration and liquidity risk: a comparative analysis of dual banking system. *Journal of Islamic Accounting and Business Research*. https://doi.org/10.1108/jiabr-07-2023-0228

Al-Deek, M. Y. (2025). Liquidity Risk in Islamic Banking: Structural Challenges and Shariah-Compliant Mitigation Strategies. *Suhuf*, *37*(2), 250–262. https://doi.org/10.23917/suhuf.v37i2.13223

Çakmak, A., & Sunal, O. (2024). The Determinants of Liquidity: A Comparison of Islamic and Conventional Banks Covering the COVID-19 Period. *Turkish Journal of Islamic*

Economics, *11*(2), 17–37. https://doi.org/10.26414/a4093

Chowdhury, Uddin, M. S., Ahmmed, M., Hassan, M. R., & Kabir, M. J. (2023). Potential risks of liquidity and credit affecting the efficiency of Islamic banks in Bangladesh. *Cogent Economics and Finance*, *11*(1). https://doi.org/10.1080/23322039.2023.2209950

Dawood, H. M., Zadjali, F. A., Rawahi, M. A., Karim, S., & Mohamed, H. (2022). Business Trends &Amp; Challenges in Islamic FinTech: A Systematic Literature Review. *F1000research*, *11*, 329. https://doi.org/10.12688/f1000research.109400.1

El Khatib, A. S., & Ferreira Savoia, J. R. (2024). Islamic Financial Institutions and Stability: An Empirical Analysis. *International Journal of Economics and Finance*, *16*(7), 1. https://doi.org/10.5539/ijef.v16n7p1

Ferdous, C. S., & Miah, M. S. (2025). Liquidity Management of Islamic Banks and Conventional Banks: Evidence From IFRS 9. *Asian Journal of Accounting Research*, 1–17. https://doi.org/10.1108/ajar-10-2024-0453

Gondwe, S., Gwatidzo, T., & Mahonye, N. (2022). Bank regulation and risk-taking in sub-Sahara Africa. *Journal of Financial Regulation and Compliance*. https://doi.org/10.1108/jfrc-12-2021-0104

Hacini, I., Boulenfad, A., & Dahou, K. (2021). The Impact of Liquidity Risk Management on the Financial Performance of Saudi Arabian Banks. *Emerging Markets Journal*. https://doi.org/10.5195/emaj.2021.221

Hermuningsih, S., & Rahmawati, A. D. (2022). Integrating Bank Size, Liquidity, and Financial Performance Into Moderating Financial Technology: A Case Study Of Sharia Commercial Banks In Indonesia. *Jurnal Aplikasi Manajemen*, *20*(4), 938–949. https://doi.org/10.21776/ub.jam.2022.020.04.15

IFSB. (2025). Islamic Financial Services Industry Stability Report 2025. In *FRB Stability Report: Vol. May*. https://www.ifsb.org/wp-content/uploads/2025/05/IFSI-Stability-Report-May-2025.pdf

Javid, M., Chandia, K. E., & Zaman Malik, Q. U. (2024). Nexus of liquidity creation, profitability and bank stability with the moderating role of corruption: an empirical analysis. *Journal of Financial Crime*, *31*(6), 1332–1361. https://doi.org/10.1108/JFC-08-2023-0198

Kateb, F. E., Boulila Taktak, N., & Hassan, M. K. (2025). AAOIFI standards and income smoothing perspective in Islamic financial institutions (IFIs): a study of the MENA region. *Journal of Islamic Accounting and Business Research*, 1–17. https://doi.org/10.1108/JIABR-12-2022-0350

Kateb, I., Nafti, O., & Zeddini, A. (2023). How to improve the financial performance of Islamic banks in the MENA region? A Shariah governance perspective. *International Journal of Emerging Markets*, *20*(6), 2559–2580. https://doi.org/10.1108/ijoem-03-2023-0434

Khalaf, B. A., & Awad, A. B. (2024). Exploring the bearing of liquidity risk in the Middle East and North Africa (MENA) banks. *Cogent Economics & Finance*. https://doi.org/10.1080/23322039.2024.2330840

Kuria, J. K., Kiboi, A., & Macheru, J. (2024). Asset Quality and Financial Stability: An Empirical Review of Commercial Banks in Kenya. *Journal of Finance and Accounting*, *8*(2), 22–38. https://doi.org/10.53819/81018102t7004

Mai, X. T. T., Nguyen, H. T. N., Ngo, T., Le, T. D. Q., & Nguyen, L. P. (2023). Efficiency of the Islamic Banking Sector: Evidence from Two-Stage DEA Double Frontiers Analysis. *International Journal of Financial Studies*, *11*(1), 32.

https://doi.org/10.3390/ijfs11010032

Mateev, M., Moudud-Ul-Huq, S., & Sahyouni, A. (2021). Regulation, banking competition and risk-taking behavior in the MENA region: policy implications for Islamic banks. *Journal of Islamic Accounting and Business Research*, *13*(2), 297–337. https://doi.org/10.1108/JIABR-01-2021-0009

Mateev, M., & Nasr, T. (2023). Banking system stability in the MENA region: the impact of market power and capital requirements on banks' risk-taking behavior. *International Journal of Islamic and Middle Eastern Finance and Management*, *16*(6), 1107–1140. https://doi.org/10.1108/imefm-05-2022-0198

Mateev, M., Tariq, M. U., & Sahyouni, A. (2023). Efficiency, Market Concentration and Bank Performance During the COVID-19 Outbreak: Evidence From the MENA Region. *Plos One*, *18*(5), e0285403. https://doi.org/10.1371/journal.pone.0285403

Mohamad, N. I., Muhamad, N. A. I., Othman, J., Anuar, A., & Nejad, M. Y. (2022). Awareness Towards Selection of Islamic Credit Card Among Malaysian Consumers. *International Journal of Academic Research in Economics and Management Sciences*, *11*(2). https://doi.org/10.6007/ijarems/v11-i2/13160

Mohd Zain, F. A., Wan Abdullah, W. A., & Percy, M. (2021). Voluntary adoption of AAOIFI disclosure standards for takaful operators: the role of governance. *Journal of Islamic Accounting and Business Research*, *12*(4), 593–622. https://doi.org/10.1108/JIABR-08-2018-0119

Mustafa, O. A. O. (2020). Impact of Liquidity Shortage Risk on Financial Performance of Sudanese Islamic Banks. *International Journal of Islamic Economics and Finance (Ijief)*, *3*(2). https://doi.org/10.18196/ijief.3229

Pusparini, M. D., Atmaja, F. F., Hidayat, A. R., Fiddareini, F., & Fachri, Z. M. (2023). Enhancing the financial stability of families by promoting knowledge and planning in Islamic finance. *Asian Journal of Community Services*, *2*(6), 529–540. https://doi.org/10.55927/ajcs.v2i6.4670

Rusydiana, A. S., & As-Salafiyah, A. (2021). Dea window analysis for Indonesian Islamic banks' efficiency. *Journal of Islamic Monetary Economics and Finance*. https://doi.org/10.21098/jimf.v7i4.1410

Safdar, R., Fatima, A., & Sajid, M. (2024). Efficiency, liquidity risk and asset quality: a comparative analysis of Islamic and conventional banks in Pakistan. *Journal of Islamic Accounting and Business Research*, *ahead-of-p*(ahead-of-print). https://doi.org/10.1108/JIABR-03-2023-0079

Samad, A. (2024). Islamic Banks' Bootstrap Efficiency and Its Determinants: Cross Country Evidence from Nine South and Southeast Asian Countries. *Journal of Accounting and Finance*. https://doi.org/10.33423/jaf.v24i5.7429

Sherif, M., & Hussnain, S. (2017). Family Takaful in developing countries: the case of Middle East and North Africa (MENA). *International Journal of Islamic and Middle Eastern Finance and Management*, *10*(3), 371–399. https://doi.org/10.1108/IMEFM-01-2016-0016

Shonhadji, N. (2023). Liquidity Risk and Basel III Implementation in Southeast Asia Banking. *Jurnal Reviu Akuntansi Dan Keuangan*, *13*(2), 481–496. https://doi.org/10.22219/jrak.v13i2.25135

Simar, L., & Wilson, P. W. (2007). Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes. *Journal of Econometrics*, *136*(1), 31–64. https://doi.org/10.1016/j.jeconom.2005.07.009

Simar, L., & Wilson, P. W. (2020). Hypothesis Testing in Nonparametric Models of

Production Using Multiple Sample Splits. *Journal of Productivity Analysis*, *53*(3), 287–303. https://doi.org/10.1007/s11123-020-00574-w

Svoboda, A. (2024). Investing in the Islamic World: Opportunities, Challenges, and Implications. *Economics and Finance*, 13–21. https://doi.org/10.51586/2754-6209.2024.12.1.13.21

Tahir, M. N., & Ibrahim, S. (2020). The Performance Of Shariah-Compliant Companies During and After the Recession Period – Evidence From Companies Listed on the FTSE All World Index. *Journal of Islamic Accounting and Business Research*, *11*(3), 573–587. https://doi.org/10.1108/jiabr-07-2016-0082

Uddin, S. M. M., Akhtar, S., Qamar, F., & Al Mughairi, H. (2025). Dynamics of technical efficiency in the Indian banking sector: a metafrontier DEA approach. *Quality & Quantity*, *59*(3), 2475–2510. https://doi.org/10.1007/s11135-025-02058-1

Ullah, K., Ashfaque, M., Atiq, M., Khan, M., & Hussain, A. (2023). Shariah Capabilities and Value Propositions of Islamic Banking. *International Journal of Islamic and Middle Eastern Finance and Management*, *16*(4), 701–715. https://doi.org/10.1108/imefm-12-2019-0518

Wang, Y., Chen, L., & Cui, M. (2024). What Explains the Operational Efficiency of Listed Commercial Banks in China? Evidence From a Three-Stage DEA-tobit Modeling Analysis. *Heliyon*, *10*(13), e33716. https://doi.org/10.1016/j.heliyon.2024.e33716

Yahaya, A., Mahat, F., M.H., Y., & Matemilola, B. T. (2022). Liquidity risk and bank financial performance: an application of system GMM approach. *Journal of Financial Regulation and Compliance*, *30*(3), 312–334. https://doi.org/10.1108/JFRC-03-2021-0019