



Prudential Calibration and Regulatory Infrastructure in Emerging Islamic Banking Systems: Evidence and Policy Implications from Sub-Saharan Africa

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ABSTRACT

This study addresses the prudential calibration challenge in emerging Islamic banking systems by examining whether prevailing capital, liquidity, and governance thresholds are proportionately aligned with operational productivity. Focusing on Sub-Saharan Africa (SSA), it reframes financial soundness indicators as regulatory design variables rather than isolated performance determinants.

The study employs a bias-corrected two-stage Data Envelopment Analysis (DEA) on a balanced panel of 35 fully fledged Islamic banks in SSA over the period 2010–2024. Efficiency scores are estimated under variable returns to scale and subsequently analysed using truncated regression against CAMELS-based prudential indicators. The findings are interpreted through a regulatory calibration framework grounded in efficiency–stability trade-off theory.

Results reveal persistent inefficiencies primarily driven by scale constraints rather than managerial deficiencies. Capital adequacy does not exhibit proportional efficiency gains, liquidity strength shows only modest productivity alignment, and asset quality demonstrates a more consistent association with operational performance. The evidence suggests that mechanical prudential reinforcement in structurally shallow markets may yield diminishing productivity returns.

The study proposes a proportional prudential calibration approach integrating capital design, liquidity infrastructure development, and governance strengthening to align stability objectives with productive intermediation better.

This paper advances Islamic banking research by positioning operational efficiency as a regulatory diagnostic tool and introducing an empirically grounded prudential calibration framework for emerging financial systems.

Keywords: Prudential regulation; Islamic banking; Operational efficiency; Proportional supervision; Sub-Saharan Africa

JEL Codes: G21; G28; G32; C14; O16

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1. INTRODUCTION

1.1 Background of the Study

The pursuit of effective prudential regulation has become increasingly complex since the global financial crisis, which has increased the penetration of financial innovation for better credit, as well as an increase in cross-border integration. Current supervisory arrangements, especially those based on Basel III-inspired models, stress fundamental elements of financial stability, such as capital adequacy, liquidity resilience, and risk-sensitive governance (Kozyuk & Baranchuk, 2022). These types of frameworks are intended to strengthen the stability of the system, but their success depends upon the proportionality of calibration with market depth, institutional scale, and supervisory expertise (Ullah, 2025). In the advent of emerging banking systems, the adoption of standardized global prudential thresholds can result in unintentional trade-offs between stabilizing stability and preserving operational efficiency, notably in countries with limited financial infrastructure and effective monitoring tools (Kozyuk & Baranchuk, 2022). It is particularly difficult to balance prudential frameworks in dual or hybrid banking systems in which Islamic financial entities operate under a partially developed supervisory regime alongside traditional banks.

Islamic banking differs structurally from conventional finance because of its utilization of profit-and-loss sharing contracts, asset-backed intermediation, and prohibition on interest-based transactions (Ali et al., 2023). These differences require modifications in terms of capital treatment, liquidity management tools, and risk recognition mechanisms to reflect the unique attributes of Islamic finance. Such variations have prompted the creation of standards by regulatory authorities, notably, the Islamic Financial Services Board and the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI)—but these standards are not always implemented consistently, particularly in frontier and emerging markets (El-Halaby et al., 2020).

The region of Sub-Saharan Africa (SSA) makes an interesting setting to investigate this dynamic, given that Islamic banking had grown under the rule of supervisory systems traditionally designed for traditional financial institutions. Generally, regulatory frameworks in SSA include a subset of international Islamic standards, though they primarily preserve traditional prudential architecture (Muhammad et al., 2025). In this context, supervisory capabilities regarding Islamic financial contracts are inconsistent, with variable adherence to IFSB and AAOIFI standards across jurisdictions. Furthermore, the presence of shallow domestic capital markets and limited access to Shariah-compliant liquidity instruments limits the flexibility of the balance sheet, which creates regulatory environments in which capital buffers and liquidity ratios act differently from what would have been expected in a sufficiently developed financial capital infrastructure (Korein et al., 2021).

Islamic banks in SSA tend to maintain higher costs and smaller margins than mature Islamic finance peers, even while facing prudential criteria. It is important to note, though, that the attempts to enhance capital adequacy and liquidity ratios have not been consistent with gains in operating efficiency: do existing prudential regimes fit best to structurally constrained markets, or could the mere mechanical “compliance” with universal standards undermine the efficiency of intermediation? (Farooq et al., 2023). The literature largely addresses issues of bank efficiency, financial soundness determinants, and governance compliance. However, this

body of work frequently frames prudential regulation as something externalizing that improves financial stability, not as a calibratable policy tool. It remains to be seen how much research is carried out that connects estimates of efficiency with analysis of regulatory design in emerging Islamic banking systems marked by disconnected supervisory capacity and ill-developed financial facilities (Mateev et al., 2021).

As a result, the relationship between prudential regulation, institutional constraints, and operational efficiency is poorly understood (Gondwe et al., 2022; Mateev et al., 2021). This study seeks to fill these gaps by reconceptualizing financial soundness indicators (capital adequacy, liquidity management, asset quality, and earnings stability), not as performance determinants but as pliable regulatory levers built into institutional architectures. Based on empirical data of Islamic banks in SSA, the study implements a prudential calibration framework that harmonizes stability objectives with productivity aims. Through the perspective of operational efficiency as a regulatory diagnostic indicator of effectiveness, the study has implications for wider debates as they relate to proportional regulation, risk-based supervision, and the development of prudential levels in developing banking systems.

1.2 Problem Statement

Prudential regulation is based on the concept that stronger capital buffers, stricter liquidity norms, and enhanced monitoring by the regulators buttress institutionally resilient and sustainable operations (Addou et al., 2024). There are frameworks such as Basel III and IFSB standards which render this logic into practice with the use of quantitative thresholds, and risk-related monitoring (Addou et al., 2024; Obadire et al., 2022). But this assumption is not always true in structurally shallow and institutionally disparate markets. In nascent Islamic banking systems—especially in Sub-Saharan Africa—prudential standards often reflect oversight environments of limited market depth, scarce liquidity instruments and uneven governance capacity. In such conditions, a strong cash cushion and liquidity position could serve to stabilise balance sheets without a corresponding increase in productive intermediation (Addou et al., 2024). If there is excess capital, it may be underutilised, liquidity buffers might work mainly as a precautionary measure, and compliance burden may fall hardest on smaller institutions that operate below efficient scale. Despite adherence to formal prudential standards, Islamic banks operating in SSA are still faced with continued scale inefficiencies and low profitability compared to more developed jurisdictions (Obadire et al., 2022). This leads to calibration question whether the current prudential thresholds are adjusted for structural capacity and institutional maturity, and/or have mechanical adoption of the global standards, but are devoid of contextual optimisation. The core issue is therefore not whether operational financial indicators affect efficiency, but whether prudential frameworks are calibrated to weigh stability goals against productivity goals. It seems that the main focus of existing scholarship is to approach regulation as static background rather than an adjustable policy tool. Insufficiently studied is how prudential intensity is related to institutional depth in emerging banking systems. This gap has been addressed in this paper by treating financial soundness variables as calibration variables incorporated in regulatory framework. Applying frontier efficiency estimation as a diagnostic method, it evaluates whether observed efficiency patterns indicate regulatory alignment or potential miscalibration in emerging Islamic banking systems.

1.3 Research Question

In light of the structural and empirical tensions identified above, this study addresses the following research question:

How should prudential regulation and Islamic monetary infrastructure be calibrated to balance financial stability and operational efficiency in emerging Islamic banking systems

1.4 Contribution

This article contributes to three related discussions in the area of prudential regulation in Islamic banking, particularly in Sub-Saharan Africa (SSA). First, the model reclassifies financial soundness measures—capital adequacy, liquidity management, and asset quality—not as stand-alone determinants of performance but as critical calibration variables that are integrated into the regulatory infrastructure. By reading evidence of efficiency through a prudential lens, it becomes obvious that non-linear and context-dependent relationships may emerge in markets characterized by structural shallowness (Istaiteyeh, 2024). Secondly, this study synthesizes elements; capital calibration, liquidity infrastructure constraints, and supervisory capacity, into one analytic structure. In contrast to the conventional application of the CAMELS model, this study takes a system-level view, correlating regulatory thresholds to the level of institutional governance and prevailing environmental conditions in SSA (Korbi & Bougatef, 2017; Wiwoho et al., 2023). This framework recognises that the regulatory environment influences not only institutional actions but also the broader economic environment on which institutions act

Finally, the study also discusses a tailored prudential calibration framework, which is specifically formulated for the context of SSA and which centers not on mechanical adoption of globally recognized standardization approaches but on proportional supervision and context-specific optimization of regulatory buffers (Korein et al., 2021; Muhammad et al., 2025). Although rooted in a strong premise in real life, this framework can be easily generalized to the practice of Islamic banking in SSA and may give the country a reference that can be extended to other frontier and emerging banking systems where faster enforcement of regulation schemes might not be able to be followed up with institutional capacities. It shows that even when prudential thresholds are the same, the productivity impacts vary widely across institutions constrained by structural limitations at the individual and institutional levels and the general macro level in a wide range of countries to the extent that it adds to general debates about proportional regulation and risk-based supervision (Korbi & Bougatef, 2017).

2. LITERATURE REVIEW

2.1 Prudential and Governance Architecture in Islamic Banking

Islamic banking prudential oversight is implemented through a tiered institutional mechanism that interweaves conventional and Sharia-type regulation. Basel III sets global standards for capital adequacy, liquidity coverage, and risk-based governance, and Islamic standard-setting bodies, including the IFSB and the AAOIFI, seek to modify these principles to accommodate the specific contractual and balance-sheet aspects of Islamic finance (F. E. Kateb et al., 2025). Such investments in asset-backed financing, profit-and-loss sharing arrangements, and prohibition of interest-bearing instruments all require a restructuring in the definition of risk recognition, capital treatment, and liquidity management procedures (Putra & Al-Banna,

2025). Taken together, these frameworks aim to build resilience in addition to ensuring compliance with aspects of Sharia law.

In practice, however, such regulatory frameworks are not uniformly applied or universally applicable. However, in many emerging economies, Islamic banking has evolved within supervisory structures that were initially built for more traditional institutions, encouraging the adoption of Islamic standards incrementally rather than broadly being incorporated in the general regulatory architecture (Snjawi & Essa, 2021). Adoption of AAOIFI accounting standards and IFSB prudential guidelines is heterogeneous, which leads to different behavior related to disclosure, capital classification, and governance enforcement (F. E. Kateb et al., 2025). This inconsistency engenders disparate regulatory regimes through a lack of uniformity, in which prudential standards can not only be defined differently across countries, but also act in divergent manners even when formal adherence to global norms is asserted.

The rationale behind these prudential frameworks to regulate these organizations is that enhanced capital buffers, liquidity positions, and governance oversight are key enablers of institutional soundness and sustained performance (Farooq et al., 2023). Nevertheless, this logic is predicated on adequate market depth, multiple investment opportunities, and adequate supervisory action (Obadire et al., 2022). Under weak supporting conditions, a quantitative threshold may serve as a stabilizer, without an associated increase in productivity. Such circumstances require an examination of the respective calibration of prudential standards versus institutional maturity and market fluctuations. In other words, Basel III and associated Islamic finance regulations provide a comprehensive framework to promote resilience in banks, but they present significant hurdles and different results (Addou et al., 2024). With the difference in regulation, policies, and institutions, there is a demand for a change of paradigm to realize the effectiveness of prudential measures in the stability and performance of Islamic banking.

2.2 Efficiency–Stability Trade-Off and Proportional Regulation

Generally, the regulatory literature acknowledges that prudential reinforcement creates trade-offs for stability and intermediation efficiency. Capital buffers aim at minimising the risk of insolvency (as a risk reduction tool) yet limiting leverage and asset growth; liquidity, which supports short-term financial resilience, may limit the funds available for income-earning activities (Snjawi & Essa, 2021). Such tensions have, in turn, motivated the idea of proportional regulation that would limit the intensity of regulation to the size of the institution, risk, and institutional strength, rather than applying an arbitrary uniformity of threshold across heterogeneous markets (Athari, 2021).

In the world of Islamic banking, such dynamics can be aggravated according to the structural nature of evolving jurisdictions. Low availability of Shari‘ah-compliant liquidity instruments and shallow secondary markets have imposed limitations on its liquidity and shallow secondary credit market structures. This would cause liquidity ratios to become more like precautionary reserves rather than active intermediation tools, and not the active intermediation equipment for financial policy, rather than proactive tools of prudential actions. Likewise, over-capitalizing, for markets with little asset diversification, ratios in capital markets like this can contribute to decreasing marginal productivity effects (Korein et al., 2021). Efficiency results may serve as an indirect proxy for the interaction between prudential tools

and constraints and established structural constraints in such a setting (Mateev & Nasr, 2023). This is based on a real-world, proportional supervision principle rather than a theoretical one.

Proportional oversight does not mean a lowering of standards of regulation, but rather the need for a market-specific calibration approach. This framework recognizes that the same prudential ratios would contribute very differently depending on the depth of the market, the structure of institutional power, and the ability of enforcement (El-Halaby et al., 2020). These effects of differentiation become particularly important in the context of emerging Islamic banking systems whose regulatory importation often outstrips the pace of institutional development (M. N. Uddin et al., 2023). The aim of prudential regulation is to stabilize financial system-wide stability in a state Islamic bank. However, the interdependence of capital adequacy, liquidity management, and institutional context calls for different supervision approaches. For new markets, the use of a wide range of regulations must be properly adapted to local conditions, so that the regulatory procedures work for efficiency and stability (Athari, 2021).

2.3 Supervisory Heterogeneity and Compliance Capacity in Emerging Markets

The adequacy of prudential regulation is contingent not only on its numerical thresholds but also upon supervisory architecture and enforcement consistency (Akinbowale et al., 2025). Islamic banks in Sub-Saharan Africa (SSA) operate in hybrid regulatory frameworks, where Islamic banks have varying degrees of Sharī'ah governance integration as well as supervisory expertise and institutional coordination. Some jurisdictions require AAOIFI compliance, whereas others adopt selective elements, resulting in variation in accounting treatment and risk disclosure (Obadire et al., 2022). Variability of supervisory training and experience in Islamic finance contracts has implications for enforcement intensity. Compliance capacity is also instrumental with regard to operational outcomes. Small Islamic banks are often weak on scale and have high fixed costs, in particular for governance boards, risk management systems, and regulatory reporting (Muhammad et al., 2025). In fragmented supervisory environments, the existence of overlapping expectations from central banks, Sharī'ah advisory councils, and international standard-setting bodies could exacerbate such administrative burdens (Akinbowale et al., 2025; Korbi & Bougatef, 2017). These kinds of structural asymmetries suggest that prudential instruments do not operate uniformly; where the capital level and the liquidity ratio are the same, the actual impact may be different depending on institutional depth and supervisory capability (Korein et al., 2021; Snjawi & Essa, 2021). As a result, assessing prudential effectiveness involves the synthesis of quantitative measures with institutional context. However, patterns of efficiency in such environments might also reflect structural constraints present in the supervisory architecture as well as managerial performance.

2.4 Review of Previous Empirical Studies

In the last twenty years, the empirical literature on Islamic banking has gained ground as it has mainly analyzed efficiency measurement, financial soundness determinants, liquidity control, governance compliance, and other phenomena (Asutay et al., 2020; Korein et al., 2021; Sahyouni et al., 2021). Although this literature offers valuable information about Islamic bank performance, it is fragmented and geographically disparate, especially considering SSA. A great deal of research takes account of Islamic banks performance using frontier-based methods such as Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) (Istaiteyeh, 2024; Olohunlana et al., 2022; S. M. M. Uddin et al., 2025). Research on worldwide and MENA

instances reveals discrepancy in cost structures, technical efficiency and scale performance, noting typical scale inefficiencies and high operating expenses in structurally shallow contexts (Mateev et al., 2021). Whereas these studies measure levels of efficiency, they seldom probe into the prudential climate in which these outcomes arise.

Another strand studies the correlation between indicators of financial soundness—such as capital adequacy, asset quality, liquidity and earnings—and performance events. Shari‘ah-compliant contracts, Profit-Sharing Investment Accounts (PSIA) and Displaced Commercial Risk (DCR) shape these indicators in Islamic banking, altering the traditional risk allocation structure (Ali et al., 2023; Farooq et al., 2023; Korein et al., 2021). Nevertheless, determinant-based analyses generally adopt linear modelling frameworks with the usual assumption that prudential strengthening increases operational efficiency. Regulation is therefore considered an exogenous stabilizing backdrop and not a potentially mis-calibrated policy tool.

Liquidity management literature also draws attention to underlying constraints caused by a low number of Shari‘ah-compliant instruments and low level of interbank market development (Snjawi & Essa, 2021). Islamic banks are likely to have precautionary liquidity buffers in place to control funding risk, especially in emerging market contexts. Such buffers can improve the stability, but their interaction with operational efficiency is still underexplored especially in SSA context where Islamic monetary infrastructure is still developing (Korein et al., 2021).

Governance and compliance studies evaluate compliance with AAOIFI and Shari‘ah supervisory mechanisms, with special focus on quality of disclosure and institutional transparency (I. Kateb et al., 2023; Muhammad et al., 2025). While these studies shed light on regulatory harmonisation challenges, they rarely connect governance depth to efficiency outcomes, nor does supervisory heterogeneity appear as part of broader performance analysis. A large fraction of the research focuses on GCC, MENA, and Southeast Asia, as these markets are quite developed Islamic banking markets (Farooq et al., 2023; I. Kateb et al., 2023; Mateev & Nasr, 2023). SSA is an undercounted area, and most current studies either rely on descriptive profit comparisons or standalone determinant testing without incorporating the structural regulatory framework (Muhammad et al., 2025). Consequently, the significant contextual elements; hybrid prudential regimes, uneven supervisory capability, and shallow Islamic liquidity markets, are seldom built into the efficiency analysis (Korein et al., 2021; Obadire et al., 2022).

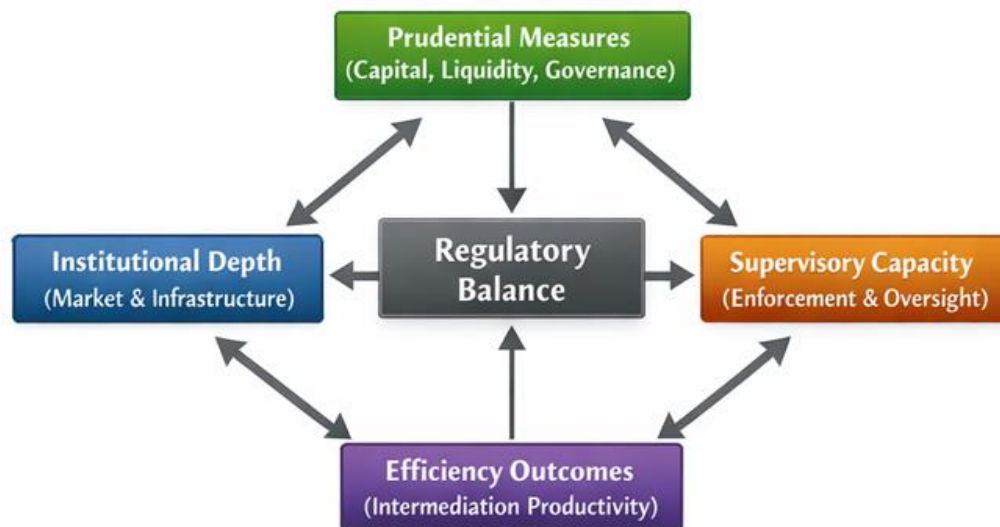
The literature combines valuable but rather compartmentalised insights. Efficiency studies measure performance, determinant research identifies statistical associations, liquidity studies expose structural constraints and studies of governance examine compliance (Al-Harbi, 2020; Istaiteyeh, 2024; Snjawi & Essa, 2021). Few studies integrate these strands into a single prudential calibration framework. The literature especially focuses on the question whether existing capital and liquidity thresholds are proportionate to institutional ability in emerging Islamic banking systems. To this end, our study contributes by re-characterizing financial soundness indicators as calibration variables that are built into the regulatory design process. Combining frontier efficiency estimation with prudential and governance perspectives in SSA contexts, rather than strictly linear determinant analysis it focuses on systemic regulatory design

analysis and provides a policy-focused view of proportional supervision of developing Islamic banking systems.

2.5 Conceptual Prudential Calibration Framework

Expanding on the theoretical framework outlined above, in this study we offer a conceptual framework for a prudential calibration framework that combines regulatory instruments, institutional depth and supervisory capacity in one analytical framework. The framework posits that such prudential instruments; for example, capital adequacy requirements, liquidity thresholds and governance standards, do not act in isolation from, rather dynamically interacting with, market infrastructure conditions and enforcement intensity. Institutional depth; manifested in the development of financial markets and liquidity mechanisms, moderates the productive effect of regulatory measures and supervisory capacity influences the constancy of implementation and efficiency of compliance. Operational efficiency outcomes are thus considered diagnostic signals of the extent to which prudential mechanisms are proportionally calibrated within a given institutional environment. This analysis below is the empirical study that seeks to assess the architecture, to determine, whether current prudential regimes in practice match the goals of stability and productive intermediation in structurally heterogeneous banking systems.

Figure 1: Conceptual Prudential Calibration Framework



3. METHODOLOGY

This study employed a quantitative research design to investigate whether existing prudential metrics are compatible with operational efficiency in emerging Islamic banking systems. The frontier estimation approach was used as a systematized regulatory diagnostic tool in assessing whether existing prudential signals fit with efficient intermediation outcomes. Rather than simply modelling efficiency, the empirical plan was aimed at generating evidence with consequences for prudential calibration and supervisory optimisation.

3.1 Data Context.

The empirical analysis relied on a balanced panel of 35 fully fledged Islamic banks operating across SSA for the period 2010–2024 with a total bank–year count of 525 observations. The case study captured both post-global financial crisis regulation changes, Basel III implementation dynamics and the slow, but continuous institutionalisation of Islamic banking within SSA supervisory systems (Tagkalakis & Kasselaki, 2023). The banks were spread across highly individual jurisdictions with varying degrees of Shari‘ah governance embedding, supervision and Islamic liquidity infrastructure building capabilities. This heterogeneity lent itself well to assessing whether uniform prudential indicators result in equivalent efficiency gains in structurally constrained settings. Annual financial data were gathered from audited documents and regulatory filings. Variables were also created to account for the realities of Islamic intermediation but to be comparable between jurisdictions.

In order to clarify the empirical structure of the study, Table 1 summarises the variables used in the analysis, their respective measurement proxies, expected relationships with operational efficiency, and supporting theoretical foundations. The variables were selected based on prudential regulation theory, the CAMELS framework, and prior DEA-based Islamic banking efficiency studies.

Table 1: Definition and Measurement of Variables

Variable	Measurement/Proxy	Expected Relationship	Theoretical / Empirical Basis
Operational Efficiency	Bias-corrected VRS DEA score	Dependent Variable	Simar & Wilson (1998; 2007); Istaiteyeh (2024); Uddin et al. (2025)
Capital Adequacy	CAR or Equity/Total Assets	±	Basel III; IFSB; Korbi & Bougatef (2017); Addou et al. (2024); Korein et al. (2021)
Liquidity Management	Liquid Assets/Deposits	+	CAMELS framework; Snjawawi & Essa (2021); Al-Harbi (2020); Sahyouni et al. (2021)
Asset Quality	Non-performing Financing Ratio	–	CAMELS framework; Mathuva (2025); Istaiteyeh (2024); Uddin et al. (2023)
Earnings Quality	ROA / Profit Margin	+	CAMELS framework; Mateev et al. (2021); Farooq et al. (2023); Sahyouni et al. (2021)
Bank Size	Natural log of Total Assets	±	Banking efficiency literature; Olohunlana et al. (2022); Mateev & Nasr (2023); Obadire et al. (2022)
Bank Age	Years since establishment	+	Institutional learning theory; Muhammad et al. (2025); Korein et al. (2021); Gondwe et al. (2022)

3.2 Estimation of Regulatory Diagnostic Efficiency.

Operational efficiency was estimated through a bias-corrected two-stage Data Envelopment Analysis (DEA) framework based upon Simar and Wilson (2007). Based on the multi-input, multi-output banking environments, DEA is well-suited for comparative

comparison of relative performance without limiting functional assumptions (Simar & Wilson, 2007). In the first step, I estimate technical and scale efficiency according to different specifications based on a Variable Returns to Scale (VRS), which represents heterogeneous size over different banks and jurisdictions. The inputs captured the intermediation resources (deposits, operating expenditures and fixed assets), and the outputs were income generating activities consistent with Islamic financing schemes. In order to improve the reliability of a mixed and mild sample, we conducted bootstrapping to generate bias corrected efficiency scores and confidence intervals (Simar & Wilson, 1998). This corrected potential upward bias in standard DEA estimates and enhances its inferential robustness. Importantly, efficiency estimates are understood as regulatory diagnostic indicators, not definitive signals about managerial capability. Sustained scale inefficiencies may suggest structural or supervisory limitations, and lack of response to amplified prudential signs may indicate calibration mismatch.

3.3 Interaction analysis of Prudential Indicators.

In the second, truncated regression analysis for the analysis was conducted to study the effect of bias-corrected efficiency scores in the interaction with financial soundness indicators by using the CAMELS framework that has been extended to Islamic banking (S. M. M. Uddin et al., 2025). Capital adequacy, asset quality, liquidity management and earnings quality were independent parameters, other controls like bank size and bank age were structural. The truncated regression specification was in accordance with the finite nature of DEA efficiency scores (Istaiteyeh, 2024). Bootstrapped standard errors served to preserve methodological coherence with the first-stage estimation (Simar & Wilson, 1998). The second-stage results were designed to guide structured inference rather than conclude causative relationships beyond doubt. The goal was to detect if bolstered prudential positions follow a proportional efficiency increase, providing diagnosis clues to possible stability–productivity trade-offs within the current regulatory framework.

3.4 Extension of regulatory calibration.

Following empirical estimation, results were assessed through a prudential calibration. Financial soundness indicators were observed and overlaid with relevant regulatory tools, such as capital buffer clauses, liquidity governance structures, and supervisory asset-quality monitoring instruments. By considering prudential indicators not just as explanatory variables, the analysis reconceptualized them as flexible regulatory levers built in to institutional architecture. Attention to patterns associated with reducing marginal efficiency returns, structural scale limitations and diverse enforcement environments was also key. This extension combined empirical findings with efficiency–stability trade-off theory and proportional regulation doctrine. The methodological framework thus extended beyond performance measurement to regulatory design evaluation, allowing the study to provide policy-relevant insights for supervisory authorities operating in structurally shallow and institutionally heterogeneous Islamic banking systems.

4. EMPIRICAL RESULTS AND REGULATORY IMPLICATIONS

4.1 Descriptive Statistics and Data Characteristics

The empirical analysis was based on 525 bank–year observations derived from 35 fully fledged Islamic banks operating in Sub-Saharan Africa over the period 2010–2024.

Table 2: Descriptive Statistics of DEA Inputs and Outputs

Variable	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
Non-Interest Expenses	13,250.75	4,441.75	522,356	0	36,743.8	8.644	98.211
Total Operating Expenses	18,874.5	11,046.6	794,811	5.73	43,156.8	12.66	210.35
Net Impairment Charges	2,698.1	1,000.98	60,773.9	0	5,532.53	5.602	44.266
Non-Interest Income	16,566.2	8,961.96	467,314	0	29,639.5	8.102	107.916
Net Fees & Commission	6,377.4	3,017.5	141,884	0	11,279	5.388	48.554
Total Other Income	11,882.5	4,527.98	279,319	0	21,772.3	5.702	54.725

The statistics revealed substantial heterogeneity in cost structures and income-generation capacity across SSA Islamic banks. Operating expenses and income variables exhibited extreme positive skewness and kurtosis, indicating high dispersion and scale asymmetry. These patterns justified the use of DEA, which does not impose parametric distributional assumptions.

4.2 Efficiency Scores: Technical versus Scale Effects

Table 3: Summary Efficiency Scores (2010–2024)

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

The mean CRS efficiency score of 0.287 in table 3 above indicated that Islamic banks could theoretically reduce inputs by approximately 71.3% without reducing output. However, the higher VRS efficiency score of 0.417 suggested that a substantial portion of inefficiency was attributable to scale effects rather than pure managerial inefficiency. Scale efficiency averaged 0.751, indicating that structural factors—such as market size, financial depth, and regulatory architecture—played a dominant role in shaping operational performance. After applying the Simar–Wilson bootstrap correction, the mean VRS efficiency declined from 0.417 to 0.318. This adjustment confirmed that conventional DEA overstated efficiency levels. The bias-corrected average of 0.318 demonstrated persistent pure technical inefficiency across SSA Islamic banks. The magnitude of correction underscored the importance of employing bias-adjusted methods in small and heterogeneous emerging markets.

4.3 Determinants of Operational Efficiency

The second-stage regression examined the relationship between financial soundness indicators and bias-corrected VRS efficiency scores.

Table 4: Full Moderated Model Results

Variable	Coefficient	p-value
Earnings Quality	−0.00087	0.001
Liquidity Management	0.00288	0.064
Asset Quality	0.00046	0.060
Capital Adequacy	−0.00132	0.262
Bank Size	−0.01298	0.185
Bank Age	0.00963	0.021

The model was jointly significant ($F = 2.52$, $p = 0.004$), although explanatory power remained modest ($R^2 = 0.056$)

The findings revealed a statistically significant negative relationship between earnings quality and operational efficiency ($\beta = -0.00087$, $p = 0.001$). This suggests that higher profitability levels among SSA Islamic banks were not necessarily associated with more efficient intermediation processes. Empirically, this outcome aligns with studies showing that banks operating in structurally shallow markets may achieve profitability through pricing power, high financing margins, or conservative financing strategies rather than through cost-efficient operations (Mateev et al., 2021). In emerging Islamic banking systems, profitability may therefore reflect risk-pricing behaviour and market segmentation effects rather than productive efficiency gains.

Liquidity management exhibited a positive but only marginally significant association with operational efficiency ($\beta = 0.00288$, $p = 0.064$). The findings imply that stronger liquidity positions contributed modestly to productive intermediation but did not generate substantial efficiency improvements. This outcome is consistent with empirical evidence from emerging Islamic banking markets where precautionary liquidity holdings are often maintained because of underdeveloped Shari'ah-compliant interbank markets and limited Islamic monetary instruments (Korein et al., 2021; Snjawy & Essa, 2021). Under such institutional conditions, liquidity buffers primarily serve stability and solvency functions rather than supporting active asset transformation and financing expansion. Consequently, the productivity benefits of higher liquidity positions remain constrained in structurally shallow markets.

Asset quality demonstrated a positive relationship with operational efficiency ($\beta = 0.00046$, $p = 0.060$), indicating that stronger financing portfolio performance was associated with improved operational outcomes. This finding is empirically supported by studies showing that lower non-performing financing exposure reduces monitoring, restructuring, and provisioning costs, thereby improving institutional resource utilisation and cost efficiency (Istaiteyeh, 2024; M. N. Uddin et al., 2023). In Islamic banking systems, where financing contracts often involve closer asset monitoring and contractual complexity, deterioration in asset quality can generate disproportionately high operational costs. The positive coefficient therefore reinforces the importance of prudent financing supervision and effective credit-risk governance mechanisms in enhancing productive intermediation.

Capital adequacy exhibited a negative but statistically insignificant relationship with operational efficiency ($\beta = -0.00132$, $p = 0.262$). Although prudential theory generally associates stronger capital buffers with institutional stability, the findings suggest that higher capitalisation levels did not translate into proportional efficiency gains within SSA Islamic banking systems. Empirical literature on emerging banking systems similarly reports that excessive capitalisation may reduce leverage efficiency and constrain productive financing where financial markets remain shallow and investment opportunities limited (Addou et al., 2024; Korein et al., 2021). In SSA jurisdictions, compliance with Basel III-inspired capital requirements may impose additional opportunity and compliance costs on relatively small Islamic banks operating below efficient scale thresholds. Furthermore, limited availability of Shari'ah-compliant investment instruments constrains the productive deployment of excess capital, causing prudential strengthening to improve solvency resilience without necessarily enhancing operational productivity. The findings therefore support the proportional regulation

perspective, which argues that prudential thresholds should reflect institutional depth, supervisory capacity, and financial infrastructure conditions rather than relying solely on uniform global regulatory standards.

The coefficient for bank size was negative and statistically insignificant ($\beta = -0.01298$, $p = 0.185$), suggesting that larger institutional scale did not automatically improve efficiency outcomes. This finding supports earlier DEA studies showing that scale expansion in emerging Islamic banking systems does not necessarily generate economies of scale because operational growth may be accompanied by rising governance, compliance, and coordination costs (Mateev & Nasr, 2023; Olohunlana et al., 2022). In fragmented supervisory environments, larger institutions may face disproportionately higher regulatory and administrative burdens, limiting expected scale-efficiency advantages.

Bank age exhibited a positive and statistically significant relationship with operational efficiency ($\beta = 0.00963$, $p = 0.021$), indicating that older Islamic banks were better positioned to convert prudential improvements into productive efficiency gains. This finding empirically supports the institutional learning hypothesis, which suggests that accumulated managerial experience, regulatory familiarity, and operational adaptation improve resource utilisation over time (Muhammad et al., 2025). Older institutions are more likely to possess mature governance structures, experienced Shari'ah supervisory systems, and stronger compliance capabilities, enabling them to manage liquidity, financing quality, and regulatory requirements more efficiently than newly established banks. The result therefore highlights the importance of institutional maturity and supervisory learning in emerging Islamic banking environments.

Although the explanatory power of the model remained modest ($R^2 = 0.056$), this outcome is consistent with prior empirical studies examining bank efficiency within heterogeneous frontier markets where institutional, macroeconomic, and behavioural influences are only partially observable within panel regression frameworks (Korein et al., 2021; Muhammad et al., 2025). The relatively low R^2 further suggests that operational efficiency in SSA Islamic banking systems is influenced by broader structural conditions beyond institution-specific prudential indicators. Factors such as inflation volatility, exchange-rate instability, financial market depth, political risk, regulatory quality, and the availability of Islamic liquidity infrastructure may substantially shape efficiency outcomes across jurisdictions. Accordingly, the objective of the regression analysis was not to fully explain all efficiency variation, but rather to generate directional diagnostic evidence regarding the interaction between prudential indicators and operational performance within structurally heterogeneous Islamic banking systems.

4.4 Moderation Effects: Institutional Maturity

The age of a bank significantly moderated the relationship between financial soundness and efficiency. Interaction terms for liquidity ($p = 0.025$) and asset quality ($p = 0.009$) were also statistically significant. The joint moderation test was highly significant ($\chi^2(4) = 18.89$, $p = 0.000826$). This indicated that older banks were better able to translate improvements in liquidity and asset quality into efficiency gains, reflecting learning effects and institutional maturity advantages.

4.5 Regulatory Signals from the Empirical Evidence

The empirical results produced sharp regulatory signals. First, lack of associated efficiency gains from higher capital adequacy suggested prudential reinforcement by itself did not automatically promote productivity in structurally shallow markets. Second, while liquidity strength was positively correlated with efficiency, the small amount of effect suggested that liquidity buffers on their own were not enough to improve intermediation effectiveness. Third, the triumph of scale inefficiency over pure technical inefficiency indicated that structure and regulatory architecture (instead of managerial ability) were the main constraint on operational performance. The average bias-corrected efficiency score further reflected that the inefficiency in SSA Islamic banking was predominantly structural. Together, they indicated that it was not just prudential ratios that regulators found themselves facing problems with, but the regulation structure in relation to market depth and institutional maturity. These diagnostic signals grounded the prudential calibration framework generated in the subsequent section.

5. REGULATORY CALIBRATION ARCHITECTURE

The empirical insights give diagnostic indications on the interaction of prudential reinforcement and operational productivity within developing Islamic banking regimes. However, instead of evidence that the existing regulatory standards are less than ideal, the results suggest a need to calibrate in proportional relation with institutional depth, supervisory capacity and market infrastructure conditions. In structurally shallow financial environments, strengthened capital and liquidity positions may not automatically translate into proportionate efficiency gains (Gondwe et al., 2024). This raises issues of degree of relationship between prudential intensity and the capacity of productive intermediation.

Building on this calibration dilemma, we developed Figure 2 that gives an integrated Prudential Efficiency–Productivity Alignment Framework specific to the development of Islamic banking systems. The framework describes prudential effectiveness not as an outcome of regulatory stringency alone, but as an interaction of the appropriate context-sensitive capital design, the enablement of Islamic liquidity infrastructure, and optimisation of structural scale (Alabbad et al., 2020). It suggests that proportional capital buffers, the Shariah-compliant liquidity tools, and governance–scale alignment need to align in the system to reach a balanced efficiency–stability equilibrium (Wiwoho et al., 2023). The model rests on a prudential efficiency–productivity balance, operationalized by risk-based supervision and adaptive policy responses. Instead of viewing capital strengthening and liquidity tightening as separate policy tools, the framework treats regulatory proportionality, institutional depth, and market infrastructure readiness as the conditioning variables (Sudarwanto et al., 2023). The projected result would be improved financial stability as well as effective intermediation where prudential reinforcement supports, not impairs, productive capacity in structurally shallow Islamic banking environments.

Figure 2: Prudential calibration framework for Islamic banking

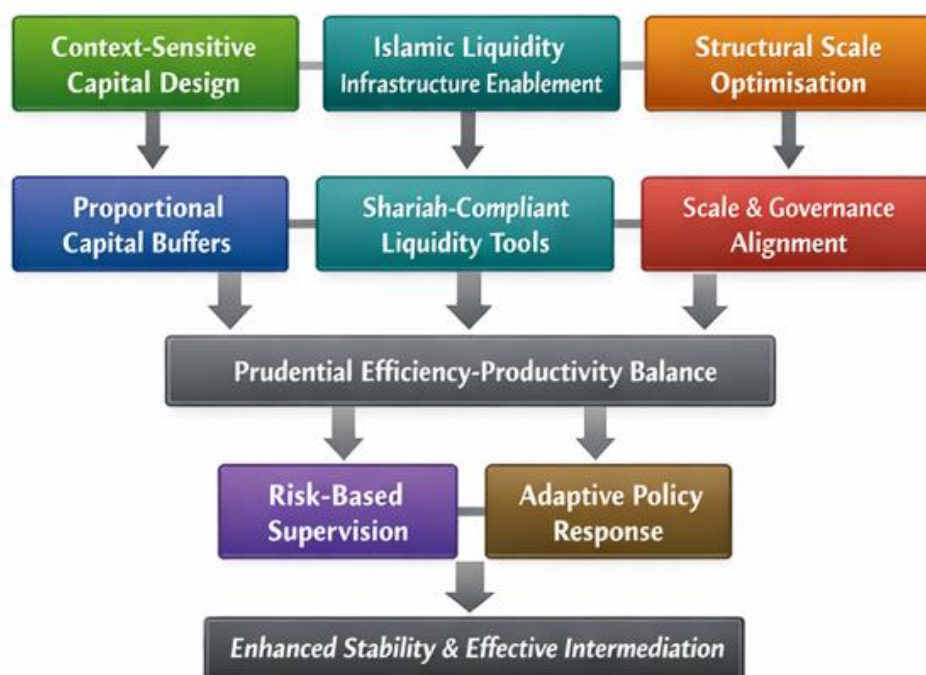


Figure 2 presents the proposed alignment framework linking prudential calibration with operational efficiency outcomes. The framework illustrates how prudential instruments interact with institutional depth and supervisory capacity to influence productive intermediation and financial stability simultaneously.

5.1 Capital Adequacy and Proportional Reinforcement

The data does not show that the positive proportional gains associated with higher capital buffers are necessarily permanent in the sample. Although enhanced solvency contributes to resilience and confidence of depositors, high capital ratios in markets with few diversified investment opportunities may have diminishing marginal productivity effects (Farooq et al., 2023; Korein et al., 2021). This trend could possibly be more a function of structural scale limitations than an example of excessive oversight. Thus, supervisory authorities also have an opportunity to assess capital calibration regimes from a perspective of proportionality, with particular reference to jurisdictions characterised by limited asset diversification and shallow capital markets. A context-appropriate method would be to calibrate capital reinforcement to the developmental trajectories of domestic financial infrastructure that can help maintain stability objectives and curb productivity trade-offs.

5.2 Liquidity Requirements and Market Depth Constraints

There is a modest and context-dependent relationship between liquidity ratios and operational efficiency. Without deep Shari‘ah-compliant money markets and secondary liquidity instruments, elevated liquidity holdings may serve mainly as precautionary buffers (Snjawi & Essa, 2021). Under such circumstances, further tightening of liquidity thresholds may yield limited incremental efficiency improvements. These results indicate that attention to supervision ought not only to extend to ratio levels, but to also develop liquidity market infrastructure and interbank mechanisms. Over time, strengthening the tradable Shari‘ah-

compliant instruments and enhancing the liquidity transmission channels could improve the effectiveness of the liquidity regulation without sacrificing prudential objectives.

5.3 Asset Quality Monitoring and Governance Capacity

Asset quality indices exhibit more consistent relationships to efficiency results, thereby suggesting that effective credit monitoring and governance mechanisms remain central to productive intermediation (Mathuva, 2025). This trend complies with principles of risk-based supervision which highlight the role of internal risk management capacity alongside quantitative buffers. To ensure that this is a priority, the supervisory authorities may want to focus on the strengthening of credit assessment frameworks, disclosure quality and governance enforcement mechanisms, especially for markets with uneven skills in supervision of Islamic financing contracts. Strengthening institutional capacities might yield more efficiency dividends than a more straightforward and numerical reinforcement of prudential thresholds alone.

5.4 Scale Constraints and Structural Heterogeneity

The continued existence in the sample of scale inefficiencies suggests that structural factors – in particular, limited market size, the cost burden of compliance and fragmented supervisory regimes – play a meaningful role in shaping performance outcomes. In environments such as these, the same prudential ratios could thus give different operational consequences depending on the level of enforcement intensity and institutional maturity. A proportional supervisory approach could accordingly involve recognising structural heterogeneity across institutions and jurisdictions. Instead of uniform intensification, calibration frameworks may benefit from gradual alignment strategies that integrate market development, supervisory capacity-building and governance strengthening alongside quantitative prudential reinforcement.

5.5 Integrating Efficiency Diagnostics into Regulatory Review

The results suggest that operational efficiency ratios could serve as complementary diagnostic tools within regulatory review. If interpreted cautiously and complemented by supervisory analysis, efficiency trends may offer early indications of potential trade-offs between stability and productivity. This diagnostic fusion does not mean deregulation or relaxation of prudential standards. Rather, it indicates the potential benefit of bringing productivity indicators to bear in proportional supervision discussions. Supervision can improve resilience and enable intermediation in emerging Islamic banking systems by aligning prudential calibration with institutional conditions and infrastructural development.

6. POLICY IMPLICATIONS

6.1 Implications for Central Banks and Supervisory Authorities in SSA

The results indicate the need for prudential reform in Islamic banking in SSA to focus on ‘contextual adaptation, rather than a one-size-fits-all ‘replication of global Basel’ banking codes. Although solvency guarantees still have to be reinforced, capital reinforcement alone would seem to not solve structural problems. Hence, central banks need to implement capital frameworks that are ‘calibrated’ for market depth, institutional maturity and systemic importance. And the supervisory authorities must also prioritise development of Islamic monetary infrastructure. Creation of local sukuk markets, Islamic liquidity facilities and Shariah-compliant lender-of-last-resort mechanisms may yield greater efficiency gains than

incremental tightening of capital or liquidity ratios. Regulatory reform, then, ought to combine prudential discipline with infrastructure enablement.

6.2 Implications for International Standard-Setting Bodies (IFSB and AAOIFI)

The findings emphasise the need for differentiated guidance tailored to emerging Islamic banking markets. In structurally shallow systems uniform prudential benchmarks might incur unintended efficiency costs. Standard-setting bodies should consider developing supplementary guidance for low-depth and frontier Islamic finance jurisdictions, incorporating scale sensitivity and infrastructure development considerations. In addition, greater emphasis should be placed on providing regulatory toolkits that support liquidity market development, supervisory harmonisation and Shari'ah governance standardisation. Strengthening implementation support mechanisms may enhance coherence across SSA jurisdictions.

6.3 Implications for Islamic Banks

The findings imply that balance-sheet expansion will not be a sufficient efficiency measure for Islamic banks across SSA. Growing scale without alignment with infrastructure could drive cost inefficiencies even more. Institutions therefore need to focus on governance strengthening, risk management capacity, and operational optimisation rather than pursuing aggressive asset growth. Implementing internal monitoring systems, asset quality controls, and integrating technologies may increase the transfer of financial soundness into operational productivity. Newly established Islamic banks should prioritise institutional learning, governance development, and supervisory adaptation mechanisms during early growth stages. The findings suggest that accumulated operational experience significantly enhances the ability of banks to transform prudential improvements into productive efficiency gains. The scale constraints may also be alleviated by strategic consolidation and regional collaboration.

6.4 Limitations of the Study

This study is limited by its reliance on institution-level secondary data and the exclusion of broader macroeconomic and country-specific governance indicators from the regression framework. Although the study employed a bias-corrected DEA approach to enhance robustness, operational efficiency outcomes may also be influenced by external structural conditions that were not fully captured in the model. Future research may integrate dynamic panel estimation techniques, macroprudential indicators, and cross-country institutional variables to further examine prudential calibration dynamics in emerging Islamic banking systems.

7. CONCLUSION

This study surveyed the relationship between the financial soundness and operational efficiency levels of Islamic banks in Sub-Saharan Africa and generalized the results to provide insight into a prudential calibration approach. Based on bias-corrected DEA estimates over the 2010–2024 period, the sample-based study findings indicated lingering inefficiencies primarily resulting from structural and scale limitations, as opposed to managerial failures. It was found that higher buffers provided by capital investments do not automatically enhance efficiency, liquidity strength alone does not guarantee productive intermediation and deterioration of asset quality is transmitted through operational stress. These results imply that under structurally shallow markets, mechanical prudential tightening induces little productivity gain. In this

context, the study adds by adding regulatory calibration as an analytical concept to Islamic banking scholarship that establishes the correlation between financial stability and operational performance in emerging markets. Combining efficiency measurement and regulatory design, it adds a context-sensitive perspective focusing on optimisation rather than unconditional reinforcement to a holistic framework. Effective regulation of Islamic banking in this context implies that there needs to be adaptive calibration of systems that reflect both market depth and institutional maturity in order to reconcile resilience and productivity in ways that are sustainable.

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