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The Impact of Technological Investment and Sukuk Activities on Islamic Bank Performance: The Moderating Role of Sharia Governance

Qonitah Rifda Zahirah[1], Slamet Haryono[1*], Julina Julina[2]

[1] Sharia Economics, Faculty of Islamic Economics and Business, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia
[2] Management, Faculty of Economics and Social Sciences, Universitas Islam Negeri Sultan Syarif Kasim, Pekanbaru, Indonesia

*Corresponding author email: slamet.haryono@uin-suka.ac.id

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ABSTRACT

Purpose: This study aims to examine the effect of technological investment components (ATM networks, software investment, and human resource expenses) and sukuk activities on the operational performance of Islamic banks in Indonesia. It addresses a gap in the literature by integrating these variables within a unified framework and by incorporating Sharia Governance as a moderating mechanism grounded in agency and stakeholder perspectives. The study also justifies the use of Return on Net Operating Assets (RNOA) as a profitability proxy that better captures operational efficiency in asset-based Islamic banking.

Method: This study employs a quantitative approach using unbalanced panel data from 14 Islamic commercial banks in Indonesia over the period 2014–2024. The analysis applies Random Effects panel regression and Moderated Regression Analysis (MRA), while controlling for bank size and Financing to Deposit Ratio (FDR).

Findings: The results show that ATM networks, human resource expenses, and sukuk activities positively and significantly affect RNOA, while software investment has no direct effect. Sharia Governance exhibits a differentiated moderating role: the Board of Directors strengthens the effect of ATM networks, the Audit Committee enhances the influence of human resource expenses, and the Sharia Supervisory Board reinforces the relationship between software investment and RNOA.

Implications: These findings suggest that Islamic banks should balance physical and digital investments, strengthen human capital, and optimize sukuk utilization, while enhancing governance effectiveness to improve operational performance.

Novelty/Value: This study contributes by integrating technological investment, sukuk activities, and multidimensional Sharia Governance within a single empirical framework, while introducing RNOA as a contextually relevant performance measure in Islamic banking.

Keywords: Islamic banking, technological investment, sukuk activities, Sharia governance, RNOA, panel data

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INTRODUCTION

Digital transformation has become a primary driver of change in the global banking industry through the adoption of FinTech, the expansion of digital services, and the utilization of artificial intelligence in core business processes (Bahoo et al., 2024; Xu et al., 2025). This shift has intensified alongside rising consumer expectations for fast, secure, and efficient financial services (Plekhanov et al., 2023). In the Indonesian context, the digital economy is projected to reach USD 109 billion by 2030, while digital banking revenue is expected to amount to USD 8.6 billion by 2029, representing a substantial increase compared to 2024 (Market Research Indonesia, 2024). The number of FinTech firms has also grown by more than 300 percent since 2017, indicating increasingly intense digital competition (Statista, 2024). This situation underscores the importance of measuring the effectiveness of digital investment, one of which is through Return on Net Operating Assets, an indicator that is free from leverage distortion (Nissim & Penman, 2003).

Despite this rapid digital expansion, Islamic banks continue to face a performance gap, where strong asset growth and increasing financial activity are not consistently accompanied by improvements in operational efficiency and profitability. Although Islamic banking assets in Indonesia grew by 14.28 percent in 2023 and financing increased by 15.45 percent, such expansion does not necessarily translate into optimal operational returns (Financial Services Authority of Indonesia, 2024). This gap reflects a critical issue in understanding whether strategic investments, particularly in technology and Sharia-compliant financial instruments, effectively generate value or merely expand scale without efficiency gains.

Empirical literature further reveals that the impact of information technology investment on bank performance remains inconclusive. Several studies find that digitalization and information technology transformation improve operational efficiency and profitability (Zhou & Xu, 2023; Alalawnh et al., 2025). In contrast, other studies report that high implementation costs, cybersecurity risks, and organizational unpreparedness may reduce the benefits of information technology or lead to insignificant outcomes (Citterio et al., 2024; Chhaidar et al., 2023). This inconsistency indicates a conceptual limitation, as technological investment is often treated as a homogeneous construct, despite consisting of heterogeneous components such as automated teller machines, software systems, and human capital investments that may exert different effects on performance (Effendi et al., 2023; Adane et al., 2021).

At the same time, Islamic banking introduces additional complexity through the use of sukuk as a Sharia-compliant funding instrument. Sukuk plays a significant role in shaping funding structure and profitability, as evidenced in prior studies across different contexts (Salhani & Mouselli, 2024; Rajaei et al., 2022). However, existing research largely examines sukuk, technological investment, or governance mechanisms in isolation. This creates a research gap, where limited attention has been given to how these elements interact within a single analytical framework to influence bank performance.

From a theoretical perspective, this study is grounded in the tension between resource allocation and governance oversight. Technological investment and sukuk activities represent strategic resource allocation decisions aimed at enhancing operational efficiency and profitability. However, in Islamic banking, such decisions are inherently constrained by Sharia principles and require effective governance to ensure both compliance and value creation. Sharia Governance mechanisms, including the Sharia Supervisory Board, the Board of Directors, and the Audit Committee, play a critical role in monitoring managerial actions and aligning them with stakeholder interests (Fatmawati et al., 2022; Abdul Rahim et al., 2024). Prior studies suggest that governance quality can strengthen investment effectiveness and mitigate operational risks (Effendi et al., 2023), yet its role is often treated as supplementary rather than as an integral moderating mechanism. This study therefore conceptualizes Sharia Governance not merely as a control system but as a moderating structure that conditions the effectiveness of technological and financial strategies, providing a clearer causal logic for their interaction.

Furthermore, this study adopts Return on Net Operating Assets (RNOA) as the primary measure of performance, addressing limitations of conventional indicators such as Return on Assets and Return on Equity that are susceptible to funding structure distortion (Fairfield & Yohn, 2001; Agburuga & Ibanichuka, 2018). Given the asset-based nature of Islamic banking, RNOA provides a more appropriate proxy for capturing operational efficiency and value creation.

Based on these considerations, this study aims to examine the effect of disaggregated technological investment components (ATM networks, software investment, and human resource expenses) and sukuk activities on the operational performance of Islamic Commercial Banks in Indonesia, while incorporating Sharia Governance as a moderating variable through its key institutional organs. By doing so, this study advances the literature by moving beyond fragmented analysis toward a conceptually integrated model that explains how resources, financial instruments, and governance mechanisms interact in shaping performance outcomes, thereby offering a more robust theoretical and empirical contribution to Islamic banking research.

LITERATURE REVIEW

This study is grounded in an integrated theoretical perspective combining the Resource Based View (RBV), agency theory, and Sharia governance framework to explain the determinants of Islamic bank performance. The Resource Based View posits that firms achieve sustainable competitive advantage through the effective utilization of valuable, rare, and inimitable resources, including technological infrastructure, financial instruments, and human capital (Barney, 1991; Maritan & Peteraf, 2011). In the banking context, these resources manifest in the form of digital investment, sukuk instruments, and organizational capabilities that directly influence operational efficiency and profitability. However, the mere availability of resources does not guarantee superior performance, as their effectiveness depends on managerial decisions and institutional structures that govern their allocation and utilization (Barney, 1991; Plekhanov et al., 2023). This limitation suggests that performance outcomes are shaped not only by resource endowment but also by governance mechanisms that ensure efficient and compliant resource deployment.

Agency theory further explains that conflicts of interest between managers and stakeholders may lead to suboptimal resource allocation, thereby reducing firm performance (Jensen & Meckling, 1976). In Islamic banking, this issue becomes more complex due to the requirement to comply with Sharia principles, which introduce ethical and religious dimensions into financial decision making (Chapra, 2001; Fatmawati et al., 2022). Sharia governance therefore plays a critical role in aligning managerial actions with both financial objectives and religious compliance through institutional mechanisms such as the Sharia Supervisory Board, the Board of Directors, and the Audit Committee (Abdul Rahim et al., 2024). Despite the importance of these elements, prior studies tend to examine technological investment, sukuk activities, and governance structures in isolation, resulting in fragmented explanations of performance. This study addresses this conceptual gap by proposing a unified framework in which technological and financial resources drive performance, while governance mechanisms condition their effectiveness, thereby resolving inconsistencies in prior findings.

Return on Net Operating Assets (RNOA)

Return on Net Operating Assets is a profitability indicator that measures a firm's ability to generate earnings from its operating assets independently of financing decisions (Nissim & Penman, 2003). This metric decomposes profitability into operating and financing components, allowing a clearer assessment of operational efficiency compared to Return on Assets and Return on Equity, which are often distorted by leverage and capital structure differences (Nissim & Penman, 2003; Agburuga & Ibanichuka, 2018). In the context of banking, particularly Islamic banking, this distinction is crucial because financial performance is heavily influenced by asset-based intermediation rather than debt driven leverage (Penman, 2013). Consequently, RNOA provides a more accurate reflection of how effectively banks utilize their operating resources to generate income.

From a theoretical perspective, RNOA represents the outcome of resource utilization as emphasized in the Resource Based View, where efficiency in managing technology, human capital, and financial assets determines value creation (Barney, 1991). However, empirical evidence suggests that improvements in digitalization do not always translate into immediate profitability gains due to implementation costs, adjustment periods, and organizational readiness constraints (Citterio et al., 2024;

Plekhanov et al., 2023). Agburuga and Ibanichuka (2018) also highlight that misclassification of operating assets may lead to overestimation of RNOA, indicating that measurement accuracy depends on proper accounting practices. These findings reveal a conceptual tension between resource investment and realized performance, suggesting that operational outcomes are contingent upon both resource efficiency and governance quality.

Number of ATM Machines

The number of Automated Teller Machines represents a physical component of technological investment that enhances accessibility, transaction efficiency, and service coverage in the banking sector. Within the RBV framework, ATM networks are considered tangible assets that can generate competitive advantage by reducing transaction costs and increasing customer convenience (Barney, 1991; Maritan & Peteraf, 2011). In emerging markets such as Indonesia, ATMs remain relevant despite the growth of digital banking, as they provide essential access for customers who are not fully integrated into digital financial systems (Otoritas Jasa Keuangan, 2024). In Islamic banking, ATM availability also contributes to service reliability and trust, which are aligned with Sharia governance principles emphasizing transparency and accessibility (Fatmawati et al., 2022).

Empirical findings, however, reveal conflicting evidence regarding the profitability impact of ATM expansion. Studies such as Kumar et al. (2022) and Yakubu and Musah (2024) show that ATM networks enhance financial inclusion and transaction volume, leading to improved profitability. Conversely, research by Cho et al. (2023) and Alali et al. (2024) indicates that the relevance of ATMs declines as mobile banking becomes dominant, reducing their contribution to performance. Adane et al. (2021) further argue that ATM deployment decisions are often driven by competitive positioning rather than profit maximization. These inconsistencies suggest that the effectiveness of ATM investment depends on the interaction between physical and digital channels, as well as cost efficiency considerations, thereby highlighting a need for further empirical investigation.

H_1: The expansion of the physical network through the number of Automated Teller Machines is positively and significantly associated with Return on Net Operating Assets in Islamic Commercial Banks in Indonesia.

Software Investment

Software investment represents an intangible form of technological resource that includes core banking systems, mobile applications, data analytics platforms, and cybersecurity infrastructure. According to the Resource-Based View, such intangible assets are critical drivers of competitive advantage when they are effectively integrated with organizational processes and capabilities (Barney, 1991; Maritan & Peteraf, 2011). In the banking sector, software enhances operational efficiency by automating processes, improving decision-making, and enabling real time service delivery (Nguyen et al., 2023). This is particularly relevant in the context of digital transformation, where banks must continuously adapt to technological changes to remain competitive (Plekhanov et al., 2023; Xu et al., 2025).

Despite its strategic importance, empirical findings on software investment remain inconsistent. While global studies demonstrate a positive relationship between IT investment and profitability (Chau et al., 2025; Chhaidar et al., 2023; Citterio et al., 2024), evidence from Indonesian Islamic banks indicates insignificant effects due to high costs, uneven digital maturity, and delayed returns (Effendi et al., 2023). This phenomenon is consistent with the productivity paradox in information technology, where substantial investments do not immediately yield measurable performance improvements. These contradictions suggest that the effectiveness of software investment depends on governance quality, human resource capability, and system integration, reinforcing the argument that technology alone is insufficient to drive performance without supporting organizational structures.

H_2: Software investment has a positive and significant impact on the improvement of Return on Net Operating Assets in Islamic commercial banks.

Human Resource Expenses

Human resource expenditure represents investment in human capital aimed at enhancing employee skills, productivity, and organizational performance (Becker, 1964). In the banking industry, human capital plays a crucial role in ensuring operational accuracy, service quality, and effective financial intermediation (Syed et al., 2022). In Islamic banking, this role is further expanded to include knowledge of Sharia principles, which is essential for maintaining compliance and institutional

credibility (Fatmawati et al., 2022). Consequently, human resource investment contributes not only to operational efficiency but also to governance effectiveness and risk management.

Empirical studies provide mixed evidence regarding the impact of human resource expenses on profitability. Grženeta et al. (2023) find that personnel costs may reduce profitability due to increased operational expenses, while Elmahdy et al. (2025) highlight their positive role in enhancing efficiency and performance. In the context of digital transformation, Shanti et al. (2023) suggest that the importance of human capital may decline as banks adopt technology-intensive business models. These findings indicate that the relationship between human resource investment and performance is contingent upon efficiency, digital maturity, and governance quality, suggesting a complex interaction that warrants further examination.

H_3: Expenditure on Human Resource Development shows a positive and significant relationship with the RNOA of Islamic Commercial Banks.

Sukuk Activities

Sukuk represent Sharia compliant financial instruments that are based on asset ownership and real economic activities, distinguishing them from conventional debt instruments (Iqbal & Mirakhor, 2011). From the RBV perspective, sukuk can be considered strategic financial assets that provide stable income streams and diversification benefits, thereby contributing to operational performance (Barney, 1991). In addition, sukuk align with the principles of Maqasid al Shariah, which emphasize fairness, risk sharing, and real sector development (Chapra, 2001; Dusuki and Bouheraoua, 2011). These characteristics make sukuk a unique component of Islamic banking that integrates financial performance with ethical considerations.

Empirical evidence generally supports a positive relationship between sukuk and bank profitability. Studies by Salhani and Mouselli (2024) and Mouselli et al. (2024) demonstrate that sukuk issuance strengthens capital structure and enhances profitability, while Rajaei et al. (2022) find similar results in different market contexts. However, the effectiveness of sukuk varies depending on governance quality, risk management, and market conditions (Effendi et al., 2023; Yudaruddin et al., 2023). These findings suggest that sukuk performance is not purely financial but is influenced by governance mechanisms, reinforcing the importance of integrating governance into the analytical framework.

H_4: Sukuk activities show a positive and significant relationship with the RNOA of Islamic Commercial Banks.

Bank Size

Bank size, represented by total assets, reflects the capacity for intermediation, funding, and operational efficiency that affects bank profitability (Nissim & Penman, 2003). From the economies of scale perspective, large banks are able to reduce unit costs and increase profitability, including RNOA, particularly when digitalization and operational structures are managed efficiently (Citterio et al., 2024; Alali et al., 2024). However, several studies indicate that excessive asset expansion may create bureaucracy, increase organizational complexity, and reduce the effectiveness of digital transformation, thereby negatively affecting efficiency (Agburuga & Ibanichuka, 2018; Plekhanov et al., 2023).

From the Resource Based View perspective, bank size reflects resource capacity to finance governance strengthening, digital investment, and human resource development (Barney, 1991; Fatmawati et al., 2022). Banks with large asset bases are also better positioned to convert technology investments into performance improvements due to more mature governance quality (Effendi et al., 2023; Bahoo et al., 2024). Nevertheless, resource advantages do not always result in efficiency when organizational structures become overly complex (Zhou & Xu, 2023; Yudaruddin et al., 2023). This variation in the effect of bank size on efficiency and profitability indicates that size may influence the relationship between the main variables and RNOA. Therefore, bank size is controlled in the empirical model to avoid omitted variable bias and to ensure that changes in RNOA are not driven by differences in asset capacity across banks.

Financing to Deposit Ratio

The Financing to Deposit Ratio reflects the extent to which third-party funds are channeled into productive financing and represents the intermediation capacity and liquidity condition of Islamic banks (OJK, 2024). An increase in this ratio may expand margin-based financing and enhance profitability when financing quality is managed prudently and in accordance with Sharia principles (Abdul Rahim et al., 2024). However, excessive financing expansion increases default risk and liquidity pressure, thereby reducing asset efficiency, including RNOA (Agburuga and Ibanichuka, 2018). Findings by Yudaruddin et al. (2023) also reveal a nonlinear pattern, whereby higher risk financing can reduce bank stability and suppress profitability.

In the context of Islamic banking, effective Sharia governance and operational digitalization play important roles in improving monitoring quality, strengthening liquidity management, and minimizing financing risk (Fatmawati et al., 2022; Effendi et al., 2023). Nevertheless, imbalances between financing distribution and funding capacity can still reduce profitability (OJK, 2024). Given these characteristics, the Financing to Deposit Ratio is controlled in the empirical model to capture variations in intermediation performance and liquidity risk, thereby ensuring that the estimated effects of the main variables on RNOA are more accurate and freer from financing risk distortion.

Sharia Governance

Sharia governance refers to the institutional framework that ensures Islamic banking operations comply with Sharia principles through oversight, accountability, and transparency (Fatmawati et al., 2022). This framework includes the Sharia Supervisory Board, the Board of Directors, and the Audit Committee, which collectively monitor managerial decisions and ensure alignment with both financial and ethical objectives (Abdul Rahim et al., 2024). From an agency theory perspective, Sharia governance mitigates conflicts of interest between managers and stakeholders by providing structured oversight and control mechanisms (Jensen & Meckling, 1976).

Empirical studies demonstrate that strong governance enhances operational efficiency and reduces risk in Islamic banking (Effendi et al., 2023). The Sharia Supervisory Board ensures compliance and ethical integrity (Chapra, 2001), while the Board of Directors and Audit Committee contribute to strategic decision making and internal control (Bahoo et al., 2024; Yudaruddin et al., 2023). However, most studies treat governance as a direct determinant rather than as a moderating mechanism. This study addresses this conceptual gap by positioning Sharia governance as a factor that conditions the effectiveness of technological investment and sukuk activities, thereby providing a more coherent explanation of performance outcomes. Six hypotheses are proposed based on the preceding discussion.

H5: The Sharia Supervisory Board is positively associated with Return on Net Operating Assets.
H6: The Board of Directors is positively associated with Return on Net Operating Assets.
H7: The Audit Committee is positively associated with Return on Net Operating Assets.
H8: The Sharia Supervisory Board moderates the relationship between technological investment, sukuk activities, and Return on Net Operating Assets.
H9: The Board of Directors moderates the relationship between technological investment, sukuk activities, and Return on Net Operating Assets.
H10: The Audit Committee moderates the relationship between technological investment, sukuk activities, and Return on Net Operating Assets.

Based on the underlying theories and prior empirical studies that inform variable formulation, the research model is developed and illustrated in Figure 1.

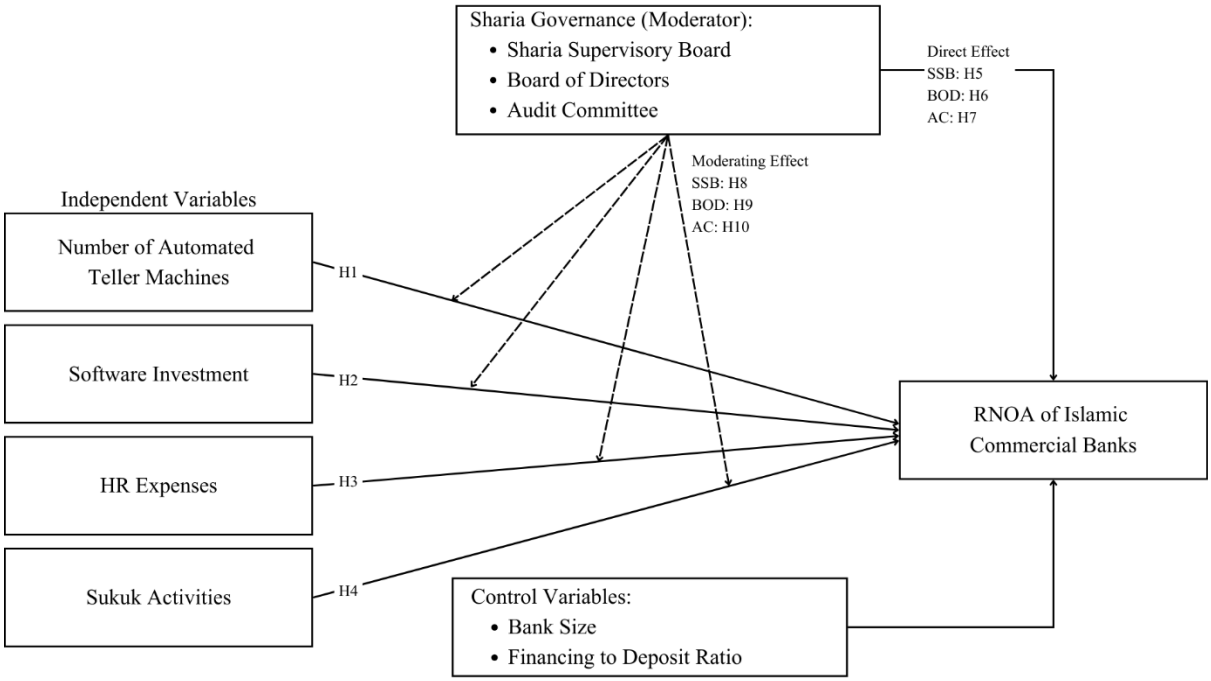


Figure 1. Research Framework
Source: processed by the author (2025)

RESEARCH METHOD

Research Design

This study employs an empirical quantitative design using a panel data approach, which is selected because it integrates the characteristics of time series and cross-sectional data, thereby providing more efficient and robust estimates (Baltagi, 2008; Gujarati & Porter, 2009). This approach is widely applied in banking research as it is capable of capturing the dynamic performance of financial institutions over time (Hsiao, 2014). Panel regression analysis is used to examine the relationships among variables, while Moderated Regression Analysis is applied to assess the role of moderating variables in strengthening or weakening these relationships (Aiken & West, 1991).

Population and Sample

The population of this study consists of fourteen Islamic commercial banks in Indonesia that are registered and supervised by the Financial Services Authority. The sample is determined using purposive sampling, a non-probability technique that selects units of analysis based on relevant criteria such as the completeness of annual reports and the suitability of data with the research objectives (Sekaran & Bougie, 2016). All Islamic commercial banks are included as the sample in order to ensure comprehensive coverage and representativeness of the national Islamic banking industry.

This study also includes three banks that later merged, namely BRI Syariah, BNI Syariah, and Mandiri Syariah, by using their respective data up to 2020, since in that year they were still operating as independent entities. Following their merger into Bank Syariah Indonesia in 2021, the data for these three banks are replaced by data from Bank Syariah Indonesia for the period 2021 to 2024. This pattern is consistent with the concept of an unbalanced panel, in which observational units may have different numbers of time periods as long as the data remain valid and representative (Wooldridge, 2010). This approach is commonly applied in banking studies because mergers change institutional identity, and therefore the use of Bank Syariah Indonesia data as a continuation after 2021 is considered

methodologically appropriate and in line with standard empirical practice. Table 1 shows the fourteen Islamic commercial banks included as samples in this study.

Table 1. Fourteen Islamic Commercial Banks

Islamic Commercial Bank	Period	Source
Bank Aceh Syariah	2014-2024	Annual Financial Report
Bank BCA Syariah	2014-2024	Annual Financial Report
Bank Pembangunan Daerah NTB Syariah	2014-2024	Annual Financial Report
Bank DPT Taspen	2014-2024	Annual Financial Report
Bank BJB Syariah	2014-2024	Annual Financial Report
Bank Mega Syariah	2014-2024	Annual Financial Report
Bank Muamalat Indonesia	2014-2024	Annual Financial Report
Bank Panin Dubai Syariah	2014-2024	Annual Financial Report
Bank Syariah Bukopin	2014-2024	Annual Financial Report
Bank Victoria Syariah	2014-2024	Annual Financial Report
Bank Syariah Indonesia	2021-2024	Annual Financial Report
Bank Syariah Mandiri	2014-2020	Annual Financial Report
Bank BNI Syariah	2014-2020	Annual Financial Report
Bank BRI Syariah	2014-2020	Annual Financial Report

Source: processed by the author (2025)

Data Collection Techniques

The data for this study were collected using secondary methods, namely data retrieval from written reports published by banking institutions, an approach commonly used in accounting and banking research (Cooper & Schindler, 2014). Data sources included annual reports from 14 Islamic Commercial Banks and Islamic Banking Statistics published by the Financial Services Authority (OJK). The use of secondary data was chosen because it provides stable, verified historical information suitable for empirical analysis in quantitative research (Saunders et al., 2019).

Operational Definition and Variable Measurement

Table 2 outlines the operational definitions and measurement indicators of variables employed in this study, derived primarily from annual financial reports of Islamic banks. The dependent construct, Return on Net Operating Assets (RNOA), captures profitability efficiency by assessing how effectively firms generate net operating profit after tax relative to net operating assets. Complementary operational variables include ATM Machines, Software Investment, and HR Expenses, which reflect the technological infrastructure and human capital development essential for banking competitiveness in the digital era. In addition, Sukuk Activities are incorporated as a categorical measure to capture sharia-based financial innovation, while Sharia Governance emphasizes institutional compliance through supervisory and audit mechanisms. To control for firm-specific characteristics, Bank Size, proxied by the natural logarithm of total assets, and Financing to Deposit Ratio (FDR), representing liquidity management, are included.

Data Analysis Techniques

This study used Eviews 13 as an analytical tool to estimate unbalanced panel data, considering the different number of observations for each bank due to the merger. Panel data analysis was chosen because it combines cross-individual and cross-time information, resulting in more efficient estimates than single cross-section or time-series regression (Baltagi, 2008; Hsiao, 2014). The panel model selection process involved three steps: the Chow Test to select between Common Effects and Fixed Effects, the Hausman Test to determine whether Fixed Effects or Random Effects were more consistent, and the Lagrange Multiplier (LM) Test to assess the feasibility of using Random Effects over Common Effects. Based on the results of these three tests, the best model was the Random Effects Model (REM). The estimation was performed using Panel Least Squares, which is econometrically implemented through Feasible Generalized Least Squares (FGLS) to ensure consistent and efficient estimators (Wooldridge, 2010).

Table 2. Operational Definition and Variables Measurements

Variables	Operational Definition	Indicator/Formula	Unit	Source
Return on Net Operating Assets (RNOA)	A profitability ratio that shows how efficiently a company generates net income from net operating assets (NOA) after tax (NOPAT).	$RNOA = \frac{NOPAT}{NOA}$	%	Annual financial report
Number of ATM Machines	The number of physical ATM units owned by the bank to serve customer transactions.	Total number of ATM units in operation	Unit	Annual financial report
Software Investment	The amount of funds spent by banks on purchasing, developing and maintaining digital/banking software.	Total software investment in financial statements	Million Rupiah	Annual financial report
HR Expenses	Cost burden for training, recruitment, and improving HR capabilities in order to build human capital.	Total cost of HR training & development	Million Rupiah	Annual financial report
Sukuk Activities	The activity of issuing, owning or transacting sukuk as a sharia-based financial instrument in banks.	Dummy: • 1 = has/issued sukuk • 0 = no	Category	Annual financial report
Sharia Governance	Sharia-based governance mechanisms through the roles of SSB, BOD, and Audit Committee to ensure compliance of bank activities with Islamic principles.	• Number of members of the Sharia Supervisory Board (SSB) • Number of members of the Board of Directors (BOD) • Number of members of the Audit Committee (AC)	Unit	Annual financial report
Bank Size	The scale of a bank's assets reflects its financial strength.	Bank Size = ln (Total Aset)	Million Rupiah	Annual financial report
Financing to Deposit Ratio (FDR)	The ratio of financing to third party funds to see the liquidity of Islamic banking.	FDR = Total Financing/Total Third Party Funds	%	Annual financial report

Source: processed by the author (2025)

Furthermore, this study applies Moderated Regression Analysis (MRA) to test the role of moderating variables. The analysis is conducted by forming interaction terms between the independent and moderating variables, estimating the interaction model using REM based on the panel model selection results, and assessing the significance of the interaction coefficients to determine whether the moderating variables strengthen or weaken the relationship between the independent and dependent variables. This approach ensures that moderation testing is conducted consistently with the panel data structure and the most appropriate econometric model.

RESULTS AND DISCUSSION

Descriptive Analysis

This section begins with a descriptive analysis to provide an overview of the characteristics and distribution of the variables used in the study. Descriptive statistics are essential for understanding the central tendency, dispersion, and overall behavior of the data prior to conducting further econometric analysis (Gujarati & Porter, 2009). By examining measures such as mean, median, standard deviation, skewness, and kurtosis, this analysis offers initial insights into the variability and potential anomalies within the dataset. Moreover, it helps identify whether the data exhibit patterns such as asymmetry or extreme values that may influence subsequent regression results (Greene, 2012). Therefore, the descriptive analysis serves as a foundational step to ensure the reliability and robustness of the empirical findings presented in the next sections.

Table 3. Descriptive Analysis Results

	RNOA	ATM	HR EXPENSES	SOFTWARE	SUKUK	DPS	BOD	AC	FDR	SIZE
Mean	2.148806	4.721791	13.14410	10.51306	0.470149	3.440299	3.589552	3.507463	85.39478	16.48336
Median	2.070000	4.625000	13.02500	10.87000	0.000000	4.000000	4.000000	4.000000	86.70000	16.40500
Maximum	15.70000	9.880000	18.42000	14.56000	2.000000	4.000000	4.000000	4.000000	196.7300	19.83000
Minimum	-29.91000	0.000000	8.410000	6.910000	0.000000	2.000000	3.000000	3.000000	38.33000	14.14000
Std. Dev.	5.382531	2.425164	2.098512	2.139528	0.645287	0.643197	0.493761	0.501820	15.94893	1.134083
Skewness	-2.794953	0.120431	0.791385	-0.127227	1.038206	-0.712371	-0.364096	-0.029854	1.896588	0.498853
Kurtosis	17.41030	3.031254	3.513884	1.595524	2.948789	2.487433	1.132566	1.000891	20.24396	3.367293
Jarque-Bera	1333.879	0.329369	15.46159	11.37492	24.08710	12.80044	22.43145	22.33334	1740.562	6.310958
Probability	0.000000	0.848161	0.000439	0.003388	0.000006	0.001661	0.000013	0.000014	0.000000	0.042618
Sum	287.9400	632.7200	1761.310	1408.750	63.00000	461.0000	481.0000	470.0000	11442.90	2208.770
Sum Sq. Dev.	3853.228	782.2290	585.6988	608.8182	55.38060	55.02239	32.42537	33.49254	33831.01	171.0572
Obs.	134	134	134	134	134	134	134	134	134	134

Source: Processed by Eviews 13 (2025)

The descriptive analysis results in Table 3 indicate strong heterogeneity across all study variables, with RNOA having a mean of 2.14 with a range of –29.91 to 15.70, reflecting the presence of very low-performing banks. This negative value occurs when NOPAT falls below zero because operating income is unable to cover operating expenses, including non-performing loan costs (Penman, 2013; Fairfield & Yohn, 2001). Other variables, such as ATM, HR Expenses, and software, also exhibit wide ranges with high standard deviations, skewness, and kurtosis, reflecting the inherent asymmetric nature of financial data.

Based on Table 3, the Jarque-Bera test, which yields a probability <0.05 for almost all variables, confirms the non-normality of the data distribution. However, this is not a methodological issue because the study uses panel data with the REM or GLS estimator, which does not require residual normality to produce consistent and efficient estimates (Wooldridge, 2010; Greene, 2012). Furthermore, in large samples, violations of normality do not compromise the validity of inferences because panel estimators are asymptotic and continue to converge to a normal distribution even when the initial data is non-normal (Gujarati & Porter, 2009). Secondary panel data, such as bank financial reports, are inherently non-normally distributed, so modern panel models such as REM, GLS, and dynamic panel approaches like GMM are designed to remain efficient under conditions of heteroscedasticity and non-normality as long as the variance and covariance structures can be estimated accurately (Ahn & Schmidt, 1995; Arellano, 2003).

Model Selection Test

Next, to determine the best model among Common Effects, Fixed Effects, and Random Effects, a series of tests are conducted: the Chow test, the Hausman test, and the Lagrange Multiplier test. Based on Table 4, the results of the model testing indicate that the Random Effects Model (REM) is the most appropriate model to use. If REM is the best model, then testing of classical assumptions such as normality, multicollinearity, heteroscedasticity, and autocorrelation is no longer necessary, because REM uses the Generalized Least Squares (GLS) estimation method which automatically addresses these issues (Gujarati & Porter, 2009).

Table 4. Model Selection Test

Model Test		Score	Best Model
Chow Test	*Prob. (F-statistic)*	0.0001	Fixed Effect
Hausman Test	*Prob. Chi-square*	0.9868	Random Effect
Lagrange Multiplier Test	*Prob. (Both) Breusch Pagan*	0.0000	Random Effect

Source: Processed by Eviews 13 (2025)

Multiple Linear Regression Analysis (Model I)

Based on previous testing, the most appropriate model was found to be the Random Effects Model, and therefore, the analysis results presented in Table 5 are based on this model.

Table 5. Multiple Linear Regression Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	30.15611	16.83197	1.791597	0.0756
ATM	1.922753	0.386504	4.974730	0.0000
HR_EXPENSES	1.026793	0.441138	2.327601	0.0215
SOFTWARE	0.191080	0.458244	0.416983	0.6774
SUKUK	0.757069	0.339801	2.227973	0.0277
DPS	7.622671	1.701782	4.479228	0.0000
BOD	-1.240805	2.185870	-0.567648	0.5713
AC	-2.048120	2.898082	-0.706716	0.4811
FDR	-0.015794	0.055800	-0.283038	0.7776
SIZE	-3.700829	0.973541	-3.801411	0.0002

Source: Processed by Eviews 13 (2025)

The Random Effect Model estimation results in Table 5 show that several independent and moderating variables have a significant influence on RNOA. The ATM variable has a positive and significant effect (coef = 1.922753; p = 0.0000), indicating that increasing the number of ATMs contributes to improving bank operational performance. The HR_EXPENSES variable also has a significant positive effect (coef = 1.026793; p = 0.0215), indicating that increasing investment in HR expenditures can improve operational efficiency, thereby increasing RNOA. Meanwhile, SOFTWARE has no significant effect (p = 0.6774), indicating that software spending has not had a direct impact on operational performance. The SUKUK variable shows a significant positive effect (coef = 0.757069; p = 0.0277), indicating that increasing the portion of sukuk can strengthen bank operational profitability.

In the moderating variables, DPS has a significant positive effect (coef = 7.622671; p = 0.0000), indicating that a strong sharia supervisory mechanism can strengthen the relationship between operational variables and RNOA. In contrast, BOD and AC are not significant (p = 0.5713 and p = 0.4811). In the control variables, FDR has no significant effect (p = 0.7776), indicating that the level of financing relative to third-party funds does not directly impact RNOA. However, SIZE has a significant negative effect (coef = –3.700829; p = 0.0002), indicating that the larger the bank size, the lower its level of operational efficiency, this is due to operational complexity and increased bureaucratic costs. Overall, these results confirm that certain aspects of digitalization (ATMs), HR expenditures, and sharia financial instruments (sukuk) are significant determinants of RNOA, while several aspects of governance and control variables do not show a significant effect.

Moderated Regression Analysis (Model II)

The following Table 6 presents the results of the analysis using Sharia Governance as a moderating variable. The moderating component of Sharia Governance consists of three main indicators: the Sharia Supervisory Board (SPS), the Board of Directors (BOD), and the Audit Committee (AC). The moderation analysis indicates that certain components of Sharia governance are able to strengthen the relationship between operational variables and RNOA, while others do not exhibit a significant moderating effect. The interaction between ATM and the Board of Directors is positive and statistically

significant, with a coefficient of 4.142597 and a probability value of 0.0000, suggesting that the effectiveness of the Board of Directors enhances the impact of ATM utilization on improvements in bank operational performance. In contrast, the interactions between ATM and the Sharia Supervisory Board and between ATM and the Audit Committee are not significant, with probability values of 0.2665 and 0.6605, respectively, indicating that these components do not moderate the relationship between ATM and RNOA.

Table 6. Moderated Regression Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	235.6973	46.52492	5.066045	0.0000
ATM_DPS	1.115090	0.998569	1.116688	0.2665
ATM_BOD	4.142597	0.865237	4.787817	0.0000
ATM_AC	0.408409	0.927463	0.440351	0.6605
HR_DPS	0.491578	0.586735	0.837820	0.4039
HR_BOD	0.939611	0.562382	1.670770	0.0975
HR_AC	1.634468	0.650629	2.512133	0.0134
SOFTWARE_DPS	1.449554	0.469345	3.088460	0.0025
SOFTWARE_BOD	-0.681246	0.528553	-1.288888	0.2000
SOFTWARE_AC	0.238773	0.630611	0.378638	0.7057
SUKUK_DPS	-0.056448	0.339974	-0.166037	0.8684
SUKUK_BOD	-0.411344	0.472445	-0.870672	0.3858
SUKUK_AC	-0.303012	0.491173	-0.616916	0.5385

Source: Processed by Eviews 13 (2025)

With respect to human resource expenses, in Table 6, the interaction between human resources and the Audit Committee is positive and significant, with a coefficient of 1.634468 and a probability value of 0.0134. This result indicates that the Audit Committee strengthens the effect of human resource expenditure on improvements in bank operational performance. Meanwhile, the interactions between human resource expenses and the Sharia Supervisory Board and between human resource expenses and the Board of Directors are not statistically significant.

For the software variable, the interaction between software investment and the Sharia Supervisory Board is positive and significant, with a coefficient of 1.449554 and a probability value of 0.0025, indicating that effective oversight by the Sharia Supervisory Board enhances the positive impact of software investment on RNOA. However, the interactions between software and the Board of Directors and between software and the Audit Committee do not show statistical significance.

Regarding sukuk, all interaction terms with the Sharia Supervisory Board, the Board of Directors, and the Audit Committee are not significant, indicating that none of the Sharia governance components moderate the relationship between sukuk and operational performance. Overall, these findings suggest that the moderating role of Sharia governance is selective, whereby the Board of Directors is effective only in moderating the relationship involving ATM, the Audit Committee is effective in moderating the relationship involving human resource expenses, and the Sharia Supervisory Board is effective in moderating the relationship involving software, while other relationships are not influenced by these Sharia governance mechanisms.

F-Test for Both Models

Based on the Table 7, Model I shows an F-statistic value of 7.594770 with a probability of 0.000 at a significance level of 5 percent.

Table 7. Results of F-Test Models I and II

Model	F-statistic	Prob(F-statistic)
Model I	7.594770	0.000000
Model II	10.19970	0.000000

Source: Processed by Eviews 13 (2025)

The finding in Table 7 indicates that the number of ATMs, human resource expenditure, software investment, three indicators in Sharia Governance, and control variables in the form of bank size and FDR simultaneously have a significant effect on RNOA in 14 Islamic banks in Indonesia during the period 2014–2024. Meanwhile, Model II produces an F-statistic value of 10.19970 with a

probability of 0.0000 at the same significance level. Therefore, it can be concluded that the combination of the number of ATMs, human resource expenditure, software investment along with moderating variables including DPS, BOD, and AC as indicators of Sharia Governance also jointly have a significant effect on RNOA in 14 Islamic banks in Indonesia throughout the research period.

Determinant Coefficients for Both Models

Based on Table 8, an R squared value of 0.355352 indicates that the independent variables in Model I explain approximately 35.5 percent of the variation in the dependent variable.

Table 8. Determinant Coefficients for Both Models

Information	R-squared
Model I	0.355352
Model II	0.417026

Source: Processed by Eviews 13 (2025)

This finding suggests that, without incorporating a moderating variable, the model's ability to explain the dynamics of the dependent variable remains at a moderate level. Accordingly, a substantial proportion of the variation in the dependent variable is likely influenced by other factors that are not yet accommodated in the model. Such a condition is common in social, behavioral, and managerial research, given that these phenomena are multidimensional in nature and involve complex determinants that cannot be fully captured within a basic regression model.

After the moderating variable is incorporated into the model through the Moderated Regression Analysis approach in Model II (see Table 8), the R squared value increases to 0.417026. This result indicates that approximately 41.7 percent of the variation in the dependent variable can be explained by the combination of independent variables, the moderating variable, and the interaction component. The increase of 6.17 percent reflects that the presence of the moderating variable adds informative value to the model, although its magnitude is not dominant. From an academic perspective, this improvement indicates that the relationship between the independent and dependent variables changes when specific conditions or characteristics captured by the moderating variable are taken into account.

The noticeable difference in R squared values between Model I and Model II represent a phenomenon that is commonly observed in moderation analysis. Statistically, the inclusion of a moderating variable and an interaction term almost always increases or at least maintains the R squared value, because the model gains additional sources of variation that potentially enhance its explanatory power (Cohen et al., 2003). Moreover, moderation models are able to capture latent relationship patterns that are not identified in regression models without moderation, resulting in a more complex variance structure that better represents the dynamics of change in the dependent variable (Hayes, 2018).

The Effect of ATM Networks on the RNOA of Islamic Commercial Banks in Indonesia

The empirical results indicate that ATM networks have a positive and significant effect on RNOA, suggesting that physical banking infrastructure continues to play a crucial role in enhancing operational performance in Islamic banks (Kumar et al., 2022; Yakubu & Musah, 2024). This finding reflects the persistent relevance of financial accessibility, particularly in emerging markets where digital penetration remains uneven (Otoritas Jasa Keuangan, 2024). ATMs contribute to increasing transaction volume, customer retention, and fee-based income, which directly improves operating returns (Adane et al., 2021). From an operational efficiency perspective, ATM networks also reduce dependency on manual services and branch-based transactions, thereby lowering operational costs (Nguyen et al., 2023). These findings support the argument that physical channels remain complementary to digital banking rather than being fully substituted (Cho et al., 2023). Consequently, ATM expansion strengthens the operational base required to generate sustainable profitability (Barney, 1991).

However, the positive effect of ATM networks is not universally supported across the literature, indicating a context-dependent relationship (Alali et al., 2024). Several studies suggest that the increasing dominance of mobile banking reduces the marginal utility of ATM infrastructure, thereby

weakening its contribution to profitability (Cho et al., 2023). Adane et al. (2021) also argue that ATM deployment is often driven by strategic positioning rather than profitability optimization, which may explain inconsistent empirical results. Furthermore, excessive investment in physical infrastructure may lead to diminishing returns when operational costs outweigh transaction benefits (Citterio et al., 2024). This contradiction highlights a critical insight that ATM effectiveness depends on its integration with digital channels rather than its standalone expansion (Plekhanov et al., 2023). Therefore, this study suggests that Islamic banks benefit from adopting a hybrid service model in which ATM networks complement digital banking to maximize operational efficiency and profitability (Nguyen et al., 2023).

The Effect of Software Investment on the RNOA of Islamic Commercial Banks in Indonesia

The results show that software investment does not have a significant effect on RNOA, indicating that digital transformation in Islamic banks has not yet translated into measurable operational profitability (Chhaidar et al., 2023). This finding aligns with the information technology productivity paradox, which suggests that technology investments often require long adaptation periods before generating financial returns (Plekhanov et al., 2023). In many cases, software systems are implemented primarily for compliance, reporting, and internal control rather than for revenue generation, limiting their direct contribution to profitability (Martins et al., 2014). Additionally, the effectiveness of software depends heavily on organizational readiness, system integration, and human resource capability (Alalawnh et al., 2025). Without these complementary factors, digital investment may function as a cost center rather than a value driver (Elmahdy et al., 2025). This explains why software investment does not immediately enhance RNOA in the context of Islamic banking (Effendi et al., 2023).

On the other hand, numerous studies provide evidence that contradicts these findings by demonstrating a positive relationship between software investment and bank performance (Chau et al., 2025; Nguyen et al., 2023). Digitalization has been shown to improve efficiency, reduce transaction costs, and enhance service innovation, leading to higher profitability (Citterio et al., 2024). The divergence between these findings suggests that the impact of software investment is highly contingent upon the stage of digital maturity and the effectiveness of implementation (Xu et al., 2025). In contexts where digital transformation is fully integrated into business processes, software investment becomes a key driver of competitive advantage (Barney, 1991). However, in transitional environments such as Indonesian Islamic banking, the benefits remain latent due to structural and institutional constraints (Effendi et al., 2023). Therefore, the nonsignificant result should be interpreted as a reflection of incomplete transformation rather than the inefficiency of technology itself (Plekhanov et al., 2023).

The Effect of Human Resource Expenses on the RNOA of Islamic Commercial Banks in Indonesia

The findings indicate that human resource expenses have a positive and significant effect on RNOA, highlighting the importance of human capital in driving operational efficiency in Islamic banks (Syed et al., 2022). Investment in employee training, digital capability, and Sharia knowledge enhances service quality and reduces operational errors, thereby improving profitability (Fatmawati et al., 2022). This result is consistent with human capital theory, which emphasizes that investment in skills and knowledge leads to higher productivity and performance (Becker, 1964). In the context of Islamic banking, human resources also play a critical role in ensuring compliance with Sharia principles, which adds value beyond operational efficiency (Chapra, 2001). Consequently, human capital becomes a strategic asset that contributes directly to sustainable competitive advantage (Barney, 1991). These findings confirm that operational performance is strongly influenced by the quality of internal capabilities (Maritan & Peteraf, 2011).

Nevertheless, the relationship between human resource expenses and profitability is not always positive, as highlighted in previous studies (Gržeta et al., 2023). High personnel costs may reduce efficiency when not accompanied by productivity improvements, thereby negatively affecting profitability (Elmahdy et al., 2025). Additionally, Shanti et al. (2023) argue that the role of human capital may decline in highly digitalized banking systems where automation replaces labor-intensive processes. These contrasting findings suggest that the effectiveness of human resource investment depends on its alignment with technological and organizational strategies (Alalawnh et al., 2025). In this study, the positive effect indicates that Islamic banks in Indonesia are still in a phase where human capital complements rather than substitutes technology (Effendi et al., 2023). Therefore, the integration of human resources with digital transformation becomes essential in maximizing operational efficiency and profitability (Plekhanov et al., 2023).

The Effect of Sukuk on the RNOA of Islamic Commercial Banks in Indonesia

Sukuk activities are found to have a positive and significant effect on RNOA, indicating their role as strategic financial instruments in enhancing Islamic bank performance (Salhani & Mouselli, 2024). Sukuk generate stable returns through asset-backed structures, which contribute to predictable income streams and improved operational profitability (Mouselli et al., 2024). This finding is consistent with the principles of Islamic finance that emphasize real sector engagement and risk sharing, which enhance financial stability (Chapra, 2001). In addition, sukuk strengthen capital structure and expand funding capacity, enabling banks to increase financing activities (Rajaei et al., 2022). As a result, sukuk contribute not only to financial returns but also to operational efficiency through improved asset utilization (Effendi et al., 2023). This reinforces the role of sukuk as a core component of Islamic banking strategy (Barney, 1991).

However, the effectiveness of sukuk is influenced by various contextual factors, leading to mixed findings in the literature (Yudaruddin et al., 2023). Some studies indicate that sukuk may expose banks to market and liquidity risks, particularly in volatile economic conditions (Rajaei et al., 2022). Additionally, the benefits of sukuk depend on governance quality and risk management practices, which determine how effectively these instruments are utilized (Effendi et al., 2023). In certain cases, weak governance structures may reduce the positive impact of sukuk on profitability (Abdul Rahim et al., 2024). This variation suggests that sukuk effectiveness is not solely determined by financial characteristics but also by institutional factors (Fatmawati et al., 2022). Therefore, the positive findings in this study highlight the importance of integrating financial innovation with strong governance to achieve sustainable performance (Chapra, 2001).

Sharia Governance as a Moderating Variable in Islamic Commercial Banks in Indonesia

Moderating Role of the Sharia Supervisory Board

The Sharia Supervisory Board significantly strengthens the relationship between software investment and RNOA, indicating that governance mechanisms enhance the effectiveness of digital transformation in Islamic banks (Fatmawati et al., 2022; Effendi et al., 2023). This finding suggests that the presence of Sharia oversight ensures that technological investments are not only compliant with Islamic principles but also aligned with operational objectives (Chapra, 2001). From an agency theory perspective, the Sharia Supervisory Board reduces information asymmetry and monitoring gaps, thereby improving the efficiency of managerial decisions related to digital investment (Jensen & Meckling, 1976). The board also plays a role in strengthening internal control systems, which enhances the reliability and effectiveness of software implementation (Abdul Rahim et al., 2024). Consequently, software investment becomes more likely to generate operational value when supported by strong governance structures (Effendi et al., 2023). This finding supports the argument that governance quality is a key determinant of technology performance outcomes (Fatmawati et al., 2022).

However, the Sharia Supervisory Board does not moderate the relationship between ATM networks, human resource expenses, and sukuk with RNOA, indicating that its influence is selective rather than universal (Abdul Rahim et al., 2024). This result suggests that the board's primary focus remains on ensuring Sharia compliance rather than directly influencing operational or strategic investment decisions (Chapra, 2001). Previous studies also highlight that governance effectiveness varies depending on the domain of decision making, with stronger influence observed in compliance-related activities rather than infrastructure or financial investment (Fatmawati et al., 2022). While Effendi et al. (2023) suggest that Sharia governance may broadly enhance performance, this study finds that its impact is more nuanced and context-specific. This inconsistency reflects the possibility that governance mechanisms are functionally differentiated and do not uniformly affect all aspects of bank operations (Abdul Rahim et al., 2024). Therefore, the moderating role of the Sharia Supervisory Board should be interpreted as contingent upon the nature of the underlying activity, particularly those related to system integrity and compliance (Chapra, 2001).

Moderating Role of the Board of Directors

The Board of Directors significantly strengthens the relationship between ATM networks and RNOA, indicating that strategic leadership plays a crucial role in optimizing the value of physical infrastructure (Citterio et al., 2024). This finding suggests that effective boards are able to align infrastructure investment with market demand and long-term business strategy (Barney, 1991). From a governance perspective, the Board of Directors ensures that resource allocation decisions are efficient and consistent with organizational objectives (Jensen & Meckling, 1976). The ability of the board to integrate physical and digital strategies enhances the productivity of ATM networks, thereby improving operational performance (Nguyen et al., 2023). This result also supports the argument that leadership quality is a critical factor in transforming resources into competitive advantage (Maritan & Peteraf, 2011). Accordingly, the moderating effect of the Board of Directors highlights the importance of strategic governance in infrastructure-based investments (Citterio et al., 2024).

In contrast, the Board of Directors does not moderate the relationship between software investment, human resource expenses, and sukuk with RNOA, suggesting limitations in its operational influence (Abdul Rahim et al., 2024). This finding indicates that the board's role is more focused on high-level strategic decisions rather than detailed operational or technological implementation (Fatmawati et al., 2022). Previous studies have shown that board effectiveness varies depending on the complexity of decision-making processes, with stronger influence observed in capital-intensive investments (Bahoo et al., 2024). While some literature suggests that boards can enhance overall firm performance, this study reveals that their impact is not uniform across all variables (Abdul Rahim et al., 2024). This inconsistency may be explained by the delegation of operational responsibilities to management and specialized committees (Jensen & Meckling, 1976). Therefore, the moderating role of the Board of Directors is context-dependent and strongest in areas related to strategic infrastructure decisions (Barney, 1991).

Moderating Role of the Audit Committee

The Audit Committee significantly strengthens the relationship between human resource expenses and RNOA, indicating that internal governance mechanisms enhance the efficiency of human capital investment (Yudaruddin et al., 2023). This finding suggests that effective monitoring and control systems ensure that human resource spending is aligned with organizational goals and delivers measurable outcomes (Effendi et al., 2023). From an agency theory perspective, the Audit Committee reduces opportunistic behavior and ensures accountability in resource allocation (Jensen & Meckling, 1976). The committee also plays a role in improving transparency and financial reporting, which enhances decision-making quality (Cohen et al., 2003). Consequently, human resource investment becomes more productive when supported by strong internal governance structures (Fatmawati et al., 2022). This finding reinforces the importance of internal control mechanisms in achieving operational efficiency (Yudaruddin et al., 2023).

However, the Audit Committee does not moderate the relationship between ATM networks, software investment, and sukuk with RNOA, indicating that its influence is limited to internal processes (Abdul Rahim et al., 2024). This result suggests that the committee's primary function is related to compliance and reporting rather than strategic or investment decisions (Cohen et al., 2003). Previous studies also highlight that audit committees are more effective in monitoring financial integrity than in influencing operational strategies (Fatmawati et al., 2022). While some research suggests that strong audit committees can enhance overall performance, this study finds that their impact is selective (Yudaruddin et al., 2023). This inconsistency reflects the functional specialization of governance mechanisms within Islamic banks (Abdul Rahim et al., 2024). Therefore, the role of the Audit Committee should be understood as complementary to other governance bodies rather than as a universal moderator (Jensen & Meckling, 1976).

Control Variables

Bank Size

Bank size plays a critical role as a control variable, reflecting the scale and resource capacity of Islamic banks in influencing operational performance (Gržeta et al., 2023). Larger banks benefit from economies of scale, which allow them to reduce average costs and improve efficiency, thereby enhancing profitability (Elmahdy et al., 2025). In addition, large banks possess greater financial and technological resources, enabling them to invest more effectively in digital transformation and

governance mechanisms (Bahoo et al., 2024). This supports the Resource-Based View, which suggests that firms with greater resource endowment have higher potential to achieve competitive advantage (Barney, 1991). Empirical evidence also indicates that larger banks are better positioned to absorb risks and adapt to market changes (Nguyen et al., 2023). Therefore, controlling for bank size ensures that the estimated effects of the main variables are not biased by differences in scale (Baltagi, 2008).

However, the relationship between bank size and performance is not always positive, as highlighted in previous studies (Agburuga & Ibanichuka, 2018). Excessive size may lead to bureaucratic inefficiencies, increased complexity, and slower decision-making processes, which can reduce operational efficiency (Plekhanov et al., 2023). Gržeta et al. (2023) also show that large banks may face diminishing returns due to regulatory constraints and higher compliance costs. Furthermore, Elmahdy et al. (2025) suggest that the benefits of size depend on the effectiveness of management and governance structures. This indicates that bank size has a dual effect, where it can both enhance and hinder performance depending on organizational conditions (Barney, 1991). Therefore, the inclusion of bank size as a control variable is essential to isolate the true impact of technological investment and sukuk on RNOA (Wooldridge, 2010).

Financing to Deposit Ratio

The Financing to Deposit Ratio represents the intermediation function of Islamic banks, reflecting how effectively deposits are converted into financing activities (Otoritas Jasa Keuangan, 2024). A higher ratio indicates more active financing, which can increase profitability through margin-based income, provided that risk is well managed (Abdul Rahim et al., 2024). This finding aligns with the theory of financial intermediation, which emphasizes the role of banks in channeling funds into productive investments (Nissim & Penman, 2003). In addition, efficient intermediation enhances asset utilization, thereby improving operational performance (Effendi et al., 2023). Empirical studies also support the positive relationship between financing activity and profitability (Yakubu & Musah, 2024). Therefore, FDR is an important control variable that captures variations in bank performance related to financing intensity (Baltagi, 2008).

Nevertheless, excessive FDR may increase liquidity risk and credit risk, which can negatively affect bank stability and profitability (Yudaruddin et al., 2023). Studies by Agburuga and Ibanichuka (2018) indicate that overextension of financing may reduce efficiency due to higher default risk and operational costs. This suggests a nonlinear relationship, where both low and high levels of FDR can be detrimental to performance (Plekhanov et al., 2023). Furthermore, risk management quality and governance mechanisms play a crucial role in determining the optimal level of financing (Fatmawati et al., 2022). The mixed findings in the literature highlight the complexity of the relationship between FDR and profitability (Abdul Rahim et al., 2024). Therefore, controlling for FDR allows this study to isolate the impact of core variables while accounting for variations in liquidity and risk exposure (Wooldridge, 2010).

CONCLUSION

The findings of this study indicate that the operational performance of Islamic Commercial Banks in Indonesia, as proxied by Return on Net Operating Assets, is shaped by the interaction between strategic resource allocation and governance mechanisms. Specifically, ATM networks, human resource expenses, and sukuk activities are found to enhance operational profitability, while software investment does not yet exhibit a direct and measurable impact, reflecting the transitional stage of digital transformation. Furthermore, Sharia governance demonstrates a differentiated moderating role, where the Sharia Supervisory Board strengthens the effectiveness of software investment, the Board of Directors enhances the contribution of ATM networks, and the Audit Committee reinforces the impact of human resource expenditures on performance.

From a theoretical perspective, this study contributes by integrating the Resource Based View, agency theory, and Sharia governance framework into a unified model that explains how operational

performance in Islamic banking is not solely driven by resource availability but is contingent upon governance effectiveness. The findings extend prior literature by demonstrating that technological investment and sukuk activities function as strategic resources, while Sharia governance acts as a conditioning mechanism that determines the extent to which these resources generate value. Moreover, the use of RNOA provides a more precise representation of operational efficiency in Islamic banking, thereby advancing the measurement of performance beyond conventional profitability indicators that are sensitive to leverage structures.

From a practical standpoint, the results suggest that Islamic banks should adopt a balanced investment strategy by integrating physical infrastructure with digital transformation, strengthening human capital as a key enabler of operational efficiency, and optimizing sukuk utilization as a stable and Sharia compliant source of funding. In addition, governance mechanisms should be enhanced not only to ensure compliance but also to actively support strategic decision making and value creation, particularly in aligning technological and financial investments with long term performance objectives.

This study acknowledges several limitations related to the scope of analysis, particularly the reliance on quantitative secondary data and the use of structural proxies to represent complex constructs such as digital transformation and Sharia governance. While these proxies are consistent with prior empirical studies, they may not fully capture qualitative dimensions such as governance effectiveness, decision making quality, or technological integration processes. Accordingly, future research is encouraged to incorporate mixed methods approaches, including qualitative assessments and case studies, to provide deeper insights into how governance and technological capabilities interact in practice. In addition, further studies may explore alternative measurement approaches for digitalization and sukuk activities, as well as examine cross country comparisons to enhance the generalizability of findings and develop a more comprehensive understanding of Islamic banking performance dynamics.

List of Abbreviations

RNOA – Return on Net Operating Assets
FDR – Financing to Deposit Ratio
MRA – Moderated Regression Analysis
ATM – Automated Teller Machine/ Anjungan Tunai Mandiri
OJK – Financial Services Authority of Indonesia
BOD – Board of Directors
RBV – Resource Based View
SSB – Sharia Supervisory Board (DPS - Dewan Pengawas Sharia)
HR – Human Resource
AC – Audit Committee
LM – Lagrange Multiplier
REM – Random Effects Model
FGLS – Feasible Generalized Least Squares
GLS – Generalized Least Squares
GMM – Generalized Method of Moments
NOA – Net Operating Assets
NOPAT – Net Operating Assets After Tax

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Authors' Information

Qonitah Rifda Zahirah (QRZ) is a student in the Sharia Economics Program, Faculty of Islamic Economics and Business, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia. Her academic interests include Islamic economics, Islamic finance, and socio-economic development. Email: 24208012001@student.uin-suka.ac.id

Slamet Haryono (SH) is a lecturer in the Sharia Economics Program, Faculty of Islamic Economics and Business, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia. His academic and research

interests include Islamic economics, Islamic finance, and economic development. Email: slamet.haryono@uin-suka.ac.id

Julina (J) is a lecturer in the Management Program, Faculty of Economics and Social Sciences, Universitas Islam Negeri Sultan Syarif Kasim, Pekanbaru, Indonesia. Her research interests include management, corporate finance, and business development. Email: julina@uin-suska.ac.id

Conflict of Interest

The authors declare no competing interests

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Availability of Data and Materials

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