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The Effect of Green Financing, Operational Efficiency (BOPO), and Capital Adequacy (CAR) on Profitability (ROA) of Islamic Commercial Banks in Indonesia, Period 2020-2024

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Abstract

Purpose—The purpose of this study was to examine the effect of green financing, operational efficiency, and capital adequacy on profitability in Islamic commercial banks in Indonesia for 2020-2024.

Design/methodology/approach—Panel data regression using the Common Effect Model on 55 samples (11 Islamic banks over 5 years) selected via purposive sampling. ROA as a profitability proxy, green financing by green financing proportion, BOPO for operational efficiency, and CAR for capital adequacy.

Findings—Simultaneously, green financing, BOPO, and CAR significantly affect ROA (R^2 0.6278). Partially, only BOPO is significant (β −0.0928; p 0.0000). Green Financing (p 0.3906) and CAR (p 0.8829) show no significant effect.

Originality/value—First study to simultaneously integrate Green Financing, BOPO, and CAR in a panel model exclusively for Indonesian BUS during the post-pandemic and green banking transition period, grounded in Signaling Theory, Agency Theory, and Sustainability Theory.

Research limitation and implication—Limited to 11 BUS; excludes BPRS, UUS, and macroeconomic controls. BUS management should prioritise BOPO reduction toward 75% and scale green financing to 5% of total financing. OJK should introduce graduated green financing mandates with fiscal incentives.

Keywords: Green financing, BOPO, CAR, ROA, Islamic banks
JEL Classifications: G21, G32, Q56

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1. Introduction

The Indonesian Islamic banking industry has recorded remarkable asset growth, reaching IDR 980.30 trillion in December 2024, 9.88% year-on-year increase that positions Indonesia among the top five Islamic banking markets globally (OJK, 2024). However, this asset expansion has not been consistently accompanied by stable profitability. Return on Assets (ROA) among Islamic Commercial Banks (BUS) exhibited significant volatility between 2020 and 2024, declining sharply to its lowest point during the COVID-19 pandemic before gradually recovering to 2.04% by the end of 2024. This divergence between asset growth and profitability stability signals that the drivers of Islamic bank performance are structural and multi-dimensional, extending well beyond the scale of the balance sheet.

Three structural determinants stand out as particularly consequential in shaping BUS profitability during this period. First, the Operational Efficiency Ratio (BOPO) remains a persistent structural challenge: several BUS recorded BOPO levels approaching or exceeding 85% during 2020–2021, substantially above OJK's ideal threshold of 70–80%, directly compressing net margins at a time when pandemic-induced provisions were already elevated (Safira et al., 2024). Second, the Capital Adequacy Ratio (CAR) presents a paradox relevant to profitability research: the national BUS average CAR reached 25.4% in December 2024, more than three times the minimum 8% regulatory floor, raising the question of whether excess capital reflects genuine financial resilience or, rather, inefficient capital allocation that dilutes asset returns (Amalia & Diana, 2022; OJK, 2024). Third, the mandatory integration of green financing into BUS portfolios, driven by POJK No. 51/POJK.03/2017 and the subsequent OJK Green Taxonomy (2022), introduces a variable whose net financial impact remains empirically contested: while green financing is theoretically positioned as a long-run value creator, the compliance costs of early-stage implementation may temporarily suppress profitability before the financial benefits materialise (Kayana et al., 2025; Yafie et al., 2024).

These three variables are analysed within an integrated theoretical framework drawing on three complementary theories. Signaling Theory (Ross, 1977; Spence, 1973) posits that financial ratios, particularly BOPO and CAR, and sustainability commitments such as green financing function as observable signals that credibly communicate institutional quality to depositors, investors, and regulators, thereby reducing information asymmetry and influencing funding costs and profitability. Agency Theory (Jensen & Meckling, 1976) explains how principal–agent conflicts between shareholders and bank management manifest in elevated operational costs (high BOPO) and suboptimal capital deployment (excess CAR), both of which directly suppress ROA. Sustainability Theory (Elkington, 1997) provides the conceptual foundation for understanding green financing not as a mere regulatory compliance burden, but as a long-run strategic investment that aligns environmental responsibility with financial performance through enhanced stakeholder trust, reduced climate-related credit risk, and access to sustainability-linked funding instruments. Together, these three frameworks form a coherent multi-channel explanatory structure suited to the unique institutional character of Islamic banking, where financial performance, governance quality, and social-environmental responsibility are simultaneously and institutionally intertwined.

Despite its theoretical clarity, prior empirical literature yields inconsistent findings across all three determinants, motivating the present study. For BOPO, although the majority of studies consistently document a significant negative effect on ROA (Amalia & Diana, 2022),(Patti Kesuma et al., 2025), (Rachmawati & Ambarwati, 2024), (Subari & Sudarsi, 2024), they find no significant effect during periods of high external volatility, suggesting that BOPO's impact is context-dependent and may be attenuated by macroeconomic shocks. For CAR, studies by (Khasanah et al., 2022)and (Setya Pratama, 2021) confirm a significant positive effect (Dwintama et al., 2021), (Latifah & Wirman, 2024), and (Widyastuti & Aini, 2021)report neutral or negative effects attributable to the over-capitalisation condition prevalent among Indonesian BUS. For green financing, (Anggraini et al., 2022), (Yafie et al., 2024), and (Panggabean et al., 2025) document a significant positive effect on ROA, while (Hasanah et al., 2022), (Kayana et al., 2025), and (Setiadi, 2021) find no significant relationship, attributing this to the nascent stage of green banking implementation in which compliance costs outweigh financial returns.

These empirical inconsistencies point to two structural gaps in the existing literature that this study is specifically designed to address. The first is an empirical gap: contradictory findings across BOPO, CAR, and green financing studies prevent the formation of a reliable evidence base for managerial and regulatory decision-making. For green financing, the divergence between studies finding a significant positive effect (Anggraini et al., 2022) (Panggabean et al., 2025) and those finding no effect (Hasanah et al., 2022) (Setiadi, 2021)is most plausibly explained by differences in the maturity of green banking implementation across observation periods a factor that prior studies have not explicitly controlled for. For BOPO, while the negative effect on ROA is the most consistently documented relationship in Indonesian banking research, (Subari & Sudarsi, 2024)demonstrate that this relationship can be attenuated by macroeconomic volatility, underscoring the need to test it across structurally distinct sub-periods rather than a single undifferentiated timeframe. For CAR, the divergence between the capital buffer argument and the over-capitalisation hypothesis remains unresolved specifically in the context of Indonesian BUS, whose average CAR of 25.4%, more than three times the regulatory minimum places them firmly in over-capitalised territory where prior findings from more capital-constrained settings may not apply.

The second is a contextual gap: most prior studies use data from pre- or during-pandemic periods (2016–2022) and therefore do not capture the post-pandemic recovery phase nor the intensified green banking transition that followed the enactment of the OJK Green Taxonomy 2022. This is consequential because the structural conditions of the 2020–2024 period pandemic-induced cost pressures, excess capital accumulation, and early-stage mandatory green financing compliance differ fundamentally from those of prior periods, making the direct extrapolation of earlier findings unreliable for current policy and managerial purposes. Critically, no existing study has simultaneously integrated all three variables Green Financing, BOPO, and CAR within a unified panel data model applied exclusively to BUS during this period, leaving a gap that limits the generalisability of existing knowledge to the present Indonesian Islamic banking environment.

This study addresses these gaps by examining the partial and simultaneous effects of Green Financing, BOPO, and CAR on ROA across 11 Indonesian Islamic Commercial Banks from 2020 to 2024, using panel data regression anchored in the integrated theoretical

framework of Signaling Theory, Agency Theory, and Sustainability Theory. The observation period is strategically selected to span three critical structural phases: the pandemic shock phase (2020–2021), the recovery and consolidation phase (2022–2023), and the green banking acceleration phase (2023–2024) following the enactment of the OJK Green Taxonomy. The novelty of this study lies in the simultaneous integration of all three determinants within a theoretically coherent tri-framework, applied to an exclusive BUS sample across a period of compounding structural transitions in Indonesian Islamic banking, a combination that no prior study has attempted.

Against this backdrop, this study is guided by the following research questions: (1) How does Green Financing affect the ROA of Islamic Commercial Banks in Indonesia during 2020–2024? (2) How does BOPO affect the ROA of Islamic Commercial Banks in Indonesia during 2020–2024? (3) How does CAR affect the ROA of Islamic Commercial Banks in Indonesia during 2020–2024? (4) How do Green Financing, BOPO, and CAR simultaneously affect the ROA of Islamic Commercial Banks in Indonesia during 2020–2024?

Accordingly, this study aims to: (1) examine the partial effect of Green Financing on ROA of Islamic Commercial Banks; (2) examine the partial effect of BOPO on ROA of Islamic Commercial Banks; (3) examine the partial effect of CAR on ROA of Islamic Commercial Banks; and (4) examine the simultaneous effect of Green Financing, BOPO, and CAR on ROA of Islamic Commercial Banks. The findings are expected to resolve existing empirical inconsistencies, generate actionable insights for BUS management and OJK regulators, and establish a theoretical reference point for future research on Islamic banking profitability in Indonesia.

2. Literature Review

2.1 Signaling Theory

Signaling Theory, developed by Ross (1977) and Spence (1973), argues that under conditions of information asymmetry between bank management and external parties, such as depositors, investors, and regulators. Management transmits observable signals through financial performance metrics to communicate institutional quality credibly. A signal is only effective when it is costly to imitate, which makes it a reliable indicator of true underlying performance. In the context of this study, the theory explains three distinct signaling mechanisms that operate concretely within Indonesian BUS. First, regarding Green Financing: when a BUS increases the proportion of its financing portfolio allocated to green sectors beyond the minimum POJK No. 51/POJK.03/2017 threshold, this constitutes a costly and verifiable ESG commitment signal. Depositors and institutional investors interpret this signal as indicative of superior risk management capacity and long-term strategic orientation, which reduces the bank's cost of funds through lower required deposit rates and access to sustainability-linked funding instruments such as green sukuk. As the cost of funds declines, the net income margin expands and ROA improves. In other words, a higher GF proportion generates a credible ESG signal, which in turn lowers the cost of funds, thereby widening the net margin and ultimately raising ROA. This sequential mechanism is the specific channel through which Signaling Theory grounds Hypothesis 1 in this study.

Second, regarding BOPO: a persistently high BOPO ratio transmits a negative signal of managerial inefficiency to the market. When external stakeholders observe BOPO levels

exceeding OJK's 80% healthy threshold, they interpret this as evidence of weak cost discipline, increasing their perception of institutional risk and consequently demanding higher deposit premiums. This elevates the bank's funding cost, further compressing net income. The mechanism operates as follows: when BOPO exceeds the healthy threshold, it sends a negative quality signal to the market, which leads to an elevated cost of funds, resulting in a compressed net margin and ultimately lower ROA. Conversely, BUS that credibly reduce BOPO below 80% generate a positive efficiency signal that differentiates them competitively, broadens their depositor base, and supports ROA growth.

Third, regarding CAR: an adequate CAR signals financial resilience and loss-absorbing capacity to regulators and depositors, reinforcing institutional trust. However, when CAR is sustained far above the regulatory minimum, as observed in this sample, where average CAR substantially exceeds 8%, the signal becomes ambiguous: excess capital may be interpreted as idle resource hoarding rather than productive deployment, providing no additional positive signaling benefit. Signaling Theory is therefore applied in this study to explain the external market perception channel through which all three independent variables influence profitability via stakeholder trust, funding cost, and competitive positioning within the Indonesian BUS landscape.

2.2 Agency Theory

Agency Theory, developed by Jensen and Meckling (1976), explains that contractual relationships between principals shareholders and depositors and agents, namely bank management, inevitably generate agency costs arising from conflicts of interest and information asymmetry. In the context of this study, the theory explains how these principal–agent conflicts manifest operationally through two specific variables in Indonesian BUS. Regarding BOPO: the agency conflict materialises concretely when bank management, prioritising operational comfort or departmental budget expansion over shareholder value maximisation, allows overhead expenses, personnel costs, and administrative spending to grow disproportionately relative to operational income. This behaviour, which is unobservable to principals without detailed internal access directly inflates the BOPO ratio. The causal chain operates as follows: misaligned managerial incentives lead to uncontrolled operational expenditure growth, which in turn elevates the BOPO ratio, compresses the net income margin, and ultimately results in lower ROA. In the Indonesian BUS context, where the average BOPO during 2020–2024 reached approximately 82–85%, this agency cost channel is not merely theoretical but empirically observable: each percentage-point increase in BOPO is estimated to reduce ROA by 0.0928 percentage points, meaning that a 5-point BOPO reduction from disciplined cost management could recover approximately 0.46 percentage points of ROA.

Regarding CAR, Agency Theory also explains why BUS consistently maintain CAR levels far exceeding the 8% regulatory minimum. Rather than deploying surplus capital into productive financing assets, which would generate additional income and improve ROA, management retains excess capital as an institutional safety buffer. This capital hoarding behaviour reflects a classic principal–agent misalignment: management preferences for regulatory security and reduced supervision risk override shareholders' interest in productive capital deployment and return maximisation. The mechanism operates as

follows: managerial risk-aversion drives the retention of idle capital above the productive optimum, which reduces yield-generating financing assets, dilutes the return on the total asset base, and consequently lowers ROA. OJK's mandatory capital requirements serve as an external monitoring mechanism designed to set a floor on capital adequacy, but they cannot prevent over-capitalisation when management's preference for safety exceeds the value-maximising capital ratio. In the Islamic context, this agency relationship carries an additional moral dimension grounded in the principle of *amanah*, which obligates management to act as a trustworthy steward of depositors' funds in full alignment with *maqasid al-shariah*, reinforcing the theoretical expectation that agency cost minimization is both a financial and ethical imperative for BUS management.

2.3 Sustainability Theory

Sustainability Theory, articulated through Elkington's (1997) Triple Bottom Line (TBL) framework, posits that long-run organisational value creation requires the simultaneous and balanced management of economic, environmental, and social performance dimensions. Applied to Indonesian BUS in the context of this study, the theory explains not merely that green financing matters in principle, but specifically how and through which sequential stages the profitability mechanism operates, a distinction crucial for interpreting the empirical findings of this research. The TBL mechanism unfolds in three identifiable phases within the Indonesian green banking regulatory environment.

In Phase 1 (Compliance Cost Absorption, approximately 2017–2022): following the enactment of POJK No. 51/POJK.03/2017, BUS are required to begin integrating green financing disclosures and sustainability reporting. During this phase, incremental costs dominate: banks must invest in dedicated green financing assessment units, environmental due diligence processes, sustainability reporting infrastructure, and staff training for green project evaluation. These compliance costs are incurred immediately and are reflected in elevated BOPO and temporarily suppressed ROA, even as the green financing portfolio itself remains small (averaging approximately 1–3% of total financing). The TBL economic pillar underperforms in the short term precisely because the environmental and social pillars are still being built. The causal sequence in this phase operates as follows: the green financing mandate triggers compliance cost investment, which causes short-run cost elevation, and consequently suppresses ROA. This explains why studies using pre-2022 data consistently find no significant or even negative green financing–ROA relationships.

In Phase 2 (Ecosystem Maturation and Signal Credibility, approximately 2022–2025): as the OJK Green Taxonomy (2022) provides standardised classification criteria, green financing disclosures gain comparability and credibility. BUS that have scaled their green portfolios beyond the 5% threshold begin to realise returns through three parallel sub-channels: (a) reduced climate-related credit risk provisioning, as green borrowers in renewable energy and sustainable agriculture sectors demonstrate lower default rates; (b) strengthened ESG reputation among institutional depositors and international investors, reducing cost of funds; and (c) access to sustainability-linked refinancing instruments at preferential rates. In this phase, the mechanism unfolds as follows: a scaled green portfolio generates a credible ESG signal, which simultaneously lowers credit risk, reduces the cost of

funds, and unlocks preferential refinancing access, all of which combine to expand the net margin and drive ROA improvement.

In Phase 3 (Long-Run Profitability Returns, post-2025): as green project portfolios reach operational maturity, particularly in renewable energy and green infrastructure, the long gestation investments begin generating stable, above-average cash flows with lower environmental risk provisioning. The TBL economic pillar reinforces the environmental pillar, producing the positive green financing–ROA nexus predicted by Sustainability Theory. This argument is further reinforced by Islamic finance principles, particularly *hifz al-bi'ah* (environmental preservation) within *maqasid al-shariah*, which provides a Sharia-grounded rationale that naturally complements the secular TBL sustainability case: just as Elkington's framework requires the simultaneous management of economic, environmental, and social dimensions, hifz al-bi'ah obligates BUS to embed environmental stewardship into their financing strategy as a religious duty reinforcing the TBL's long-horizon orientation and providing a faith-based rationale that accelerates green financing adoption beyond mere regulatory compliance. Sustainability Theory thus predicts that the green financing–ROA relationship in Indonesian BUS will strengthen progressively as the ecosystem matures from Phase 1 compliance cost absorption through Phase 2 credibility building to Phase 3 long-run profitability returns a temporal dynamic that the 2020–2024 observation window of this study captures at the transitional boundary between the first and second phases. The three theoretical frameworks used in this study are not mutually exclusive; they form a coherent and complementary explanatory structure. Signaling Theory explains the external market perception channel through which financial ratios and green financing commitments influence stakeholder trust and profitability. Agency Theory explains the internal governance channel through which principal-agent conflicts manifest in operational inefficiency and suboptimal capital utilization, both of which directly suppress ROA. Sustainability Theory explains the long-term value creation channel through which green financing embedded as a strategic commitment rather than a mere compliance exercise generates durable competitive advantages. Together, these three frameworks offer a multi-dimensional analytical lens that is particularly well-suited for Islamic banking research,where financial performance, governance quality, and environmental-social responsibility are simultaneously relevant and institutionally intertwined

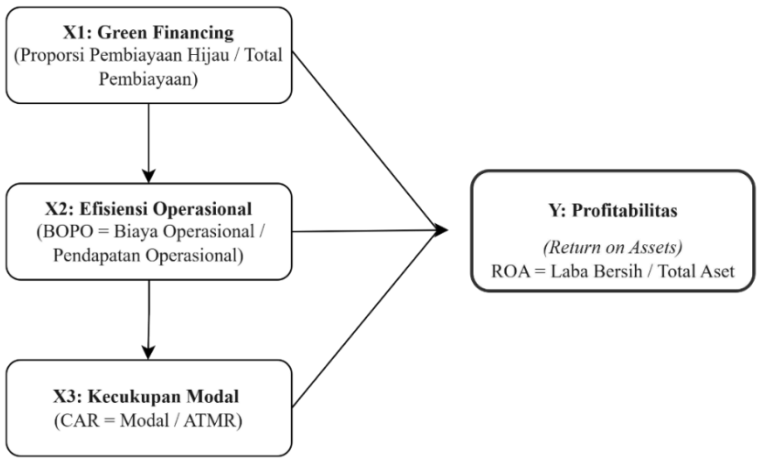


Figure 1. Conceptual Framework of the Influence of Green Financing, BOPO, and CAR on Bank Profitability

2.4 Profitability and Return on Assets

Return on Assets (ROA) serves as the dependent variable and primary profitability measure in this study, calculated as net income divided by total assets. ROA reflects management's overall effectiveness in generating earnings from the institution's entire asset base and is preferred over Return on Equity (ROE) because it is unaffected by leverage decisions, enabling neutral cross-bank comparisons regardless of capital structure differences. OJK sets a minimum healthy ROA threshold of 1.5% for commercial banks in Indonesia. During the 2020–2024 period, ROA among Indonesian BUS experienced significant volatility, declining sharply during the COVID-19 pandemic before recovering to 2.04% by December 2024 (OJK, 2024), underscoring the importance of identifying the structural determinants of profitability during this complex transitional period.

2.5 Green Financing and Its Effect on Profitability (ROA)

Green financing in this study is measured as the proportion of a BUS's total financing portfolio allocated to environmentally sustainable projects as classified under OJK's Green Taxonomy (2022), covering sectors such as renewable energy, energy efficiency, sustainable agriculture, and green infrastructure. Through the lens of Sustainability Theory, green financing generates long-run profitability by reducing climate-related credit risk, lowering risk provisioning costs, and strengthening ESG reputation among an increasingly sustainability-oriented depositor and investor base. Signaling Theory further predicts that a growing green financing ratio communicates strategic credibility and regulatory compliance to external stakeholders, supporting customer acquisition and revenue expansion that ultimately lifts ROA. Empirically, Anggraini et al. (2022), Yafie et al. (2024), and Panggabean et al. (2025) confirm a significant positive effect of green financing on ROA, consistent with the long-run value creation argument. However, (Hasanah et al., 2022), (Kayana et al., 2025), and (Setiadi, 2021) report no significant effect, attributing this to early-stage implementation costs that temporarily suppress profitability before financial benefits materialize. Given the post-OJK Green Taxonomy 2022 maturation of green banking practices among Indonesian BUS, the positive effect of green financing on profitability is expected to strengthen as implementation matures.

H1: Green financing has a significant positive effect on Islamic commercial banks' ROA.

2.6 BOPO and Its Effect on (ROA)

BOPO measures total operational expenses as a proportion of total operational income and serves as the primary proxy for cost efficiency in Indonesian banking analysis. OJK defines the efficient operating range as 70–80%, with values approaching or exceeding 85% as recorded by several BUS during the pandemic indicating serious structural inefficiency. Under Signaling Theory, a persistently high BOPO transmits a negative signal of managerial inefficiency to the market, eroding stakeholder confidence and weakening the bank's competitive position. Under Agency Theory, elevated BOPO directly reflects the materialization of agency costs, whereby management's failure to optimize cost structures in alignment with principals' interests reduces the net income margin available to generate ROA. The negative effect of BOPO on ROA is among the most consistently documented

relationships in the Indonesian banking literature, confirmed by (Amalia & Diana, 2022), (Patti Kesuma et al., 2025), (Kusnadi & Sukartaatmadja, 2022). (Setya Pratama et al., 2021), and (Rachmawati & Ambarwati, 2024). The sole exception is (Subari & Sudarsi, 2024), who find no significant effect during periods of extreme macroeconomic volatility, suggesting that external shocks may temporarily dominate internal efficiency as a profitability determinant. Based on the theoretical framework and the weight of empirical evidence, the following hypothesis is proposed.

H2: BOPO has a significant negative effect on Islamic commercial banks' ROA.

2.7 CAR and Its Effect on Profitability (ROA)

CAR (Capital Adequacy Ratio) measures a bank's capital adequacy by comparing Tier 1 and Tier 2 capital to Risk-Weighted Assets (RWA), with OJK prescribing a regulatory minimum of 8% for commercial banks. The average CAR of Indonesian BUS reached 25.4% in December 2024 (OJK, 2024) more than three times the minimum threshold creating a distinctive empirical context that simultaneously invites both the capital buffer and over-capitalization arguments. Under Signaling Theory, an adequate CAR signals financial resilience to depositors and investors, reinforcing confidence in the bank's ability to absorb unexpected losses and sustain financing growth, which supports higher ROA through expanded interest and fee income. Under Agency Theory, however, CAR levels sustained far above the productive optimum reflect a form of capital hoarding: management retains idle capital rather than deploying it into yield-generating financing assets, thereby diluting returns on the total asset base and compressing ROA a condition consistent with the over-capitalization hypothesis. Empirically, (Khasanah et al., 2022), (Suryadi et al., 2022) (Pratiwi et al., 2022) and (Wardana & Setiadi, 2023) confirm a significant positive effect of CAR on ROA, while (Latifah & Wirman, 2024),(Dwintama et al., 2021), (Widyastuti & Aini, 2021), and (Astuti, 2022) report neutral or negative effects consistent with the over-capitalization hypothesis.

H3: CAR has a positive significant effect on Islamic commercial banks' ROA.

2.8 Simultaneous Effects Towards Profitability (ROA)

In Islamic banking literature, systems theory underscores the multivariate interplay of sustainability signaling, operational optimization, and prudential buffers as complementary transmission mechanisms driving holistic financial resilience, surpassing univariate analyses' explanatory power. Drawing from panel data econometrics, simultaneous equation modeling captures endogenous interactions where strategic resource allocation enhances sharia-compliant profitability amid economic volatility, aligning with OJK's integrated risk management directives under POJK No. 18/POJK.03/2021 (Listiana, 2023). This theoretical convergence posits that joint optimization rather than isolated metrics maximizes ROA variance explanation (F-statistic superiority), particularly as Indonesian Islamic banks navigate digital acceleration, climate regulatory pressures, and Basel IV transitions, where omitted variable bias undermines single-factor inferences. (Anggraini et al., 2022) highlight single-variable studies' limitations; simultaneous green financing (legitimacy channel), BOPO (efficiency channel), and CAR (stability channel) interactions better explain ROA variance during recovery. (Listiana, 2023).

3. Research Method

This study employs a quantitative approach with a deductive-explanatory design to examine the effects of Green Financing (GF), the BOPO cost efficiency ratio, and the Capital Adequacy Ratio (CAR) on the profitability of Islamic Commercial Banks (BUS) in Indonesia, proxied by Return on Assets (ROA). The deductive approach is adopted because hypotheses are derived from established theoretical frameworks, Signaling Theory, Agency Theory, and Sustainability Theory, and subsequently tested against panel data evidence. The explanatory design is appropriate because the study aims not merely to describe observed patterns, but to explain the causal mechanisms linking the three determinants to bank profitability.

The research population comprises all 14 Islamic Commercial Banks (BUS) registered with OJK during the 2020–2024 observation period. A final sample of 11 banks was obtained through a purposive sampling non-probability technique that selects units based on pre-defined criteria relevant to the research objectives (Sekaran & Bougie, 2016). The four selection criteria applied were: (1) active registration with OJK throughout 2020–2024; (2) completeness of annual financial reports and sustainability reports for all five consecutive observation years; (3) consistent green financing disclosures compliant with POJK No. 51/POJK.03/2017 across all five years; and (4) no merger, acquisition, liquidation, or revocation of business licence during the observation period. Three banks from the original population were excluded two due to incomplete sustainability reports and one due to inconsistent green financing disclosures leaving a final sample of 11 banks. Observed over five years, this yields 55 balanced panel observations (11 banks × 5 years).

Annual rather than quarterly data are used for two principal reasons. First, green financing disclosures under POJK No. 51/POJK.03/2017 are mandated on an annual basis; quarterly reports do not consistently contain the sustainability metrics required to construct the green financing variable. Second, annual data reduce the influence of intra-year seasonal volatility in profitability ratios, consistent with prior studies on Islamic bank performance (Otero et al., 2020; Menne et al., 2022). Data were collected from secondary sources comprising: (1) OJK Annual Islamic Banking Statistics; (2) audited Annual Financial Reports from each bank's official website; and (3) Sustainability Reports submitted under POJK No. 51/POJK.03/2017. The operational definition, measurement formula, scale, and data source for each variable in this study are presented in Table 1.

Table 1. Operational Definition of Research Variables

Variable	Type	Indicator	Measurement Formula	Scale	Source
Return on Assets (ROA)	Dependent (Y)	Efficiency of asset utilisation in generating net profit	ROA = (*Net Profit / Total Average Assets*) × 100%	Ratio (%)	Annual Financial Report; OJK
Green Financing (GF)	Independent (X_1)	Proportion of financing to green sectors: renewable energy, waste management, low-emission industries	GF = (*Total Green Financing / Total Financing*) × 100%	Ratio (%)	Sustainability Report; OJK

Variable	Type	Indicator	Measurement Formula	Scale	Source
		(POJK No. 51/POJK.03/2017)			
BOPO (Cost Efficiency Ratio)	Independent (X_2)	Ratio of operating expenses to operating income. Healthy threshold: < 80% (Bank Indonesia). Lower = more efficient.	BOPO = (*Operating Expenses / Operating Income*) × 100%	Ratio (%)	Annual Financial Report; OJK
Capital Adequacy Ratio (CAR)	Independent (X_3)	Capital sufficiency relative to risk-weighted assets. Minimum: 8% (Basel III / OJK). Higher = stronger capital buffer.	CAR = (*Capital (Tier 1 + Tier 2) / Risk-Weighted Assets*) × 100%	Ratio (%)	Annual Financial Report; OJK

Source: POJK No. 51/POJK.03/2017; Bank Indonesia Regulation; OJK Annual Reports; compiled by authors (2025)

Based on the variable definitions above, the panel data regression model estimated in this study is specified as follows:

$$ROA_{it} = \beta_0 + \beta_1 GF_{it} + \beta_2 BOPO_{it} + \beta_3 CAR_{it} + \varepsilon_{it} \quad \text{..... (1)}$$

Where *ROAit* is the Return on Assets of bank *i* in year *t*; β_0 is the intercept; β_1, β_2, β_3 are regression coefficients for GF, BOPO, and CAR, respectively; and εit is the error term. Subscript *i* denotes the bank unit (i = 1,…, 11) and *t* denotes the year (t = 2020, …, 2024).

Panel data regression can be estimated using three alternative models: the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). To determine the most appropriate estimator, three sequential specification tests were conducted using EViews 12. The Chow Test evaluates whether CEM or FEM better fits the data by testing for the presence of cross-sectional fixed effects; a p-value above 0.05 retains CEM over FEM. If FEM is selected, the Hausman Test then compares FEM against REM by assessing whether individual bank effects are correlated with the regressors; a Chi^2 p-value above 0.05 favors REM. When CEM is preferred over FEM, the Lagrange Multiplier (LM) Test subsequently confirms whether CEM is also preferable to REM; a p-value above 0.05 confirms CEM as the final estimator.

3.1 Descriptive Statistics

Prior to hypothesis testing, descriptive statistics were computed for all research variables to characterize the distribution of the data. Descriptive statistics reported in this study include the number of observations (*N*), mean, standard deviation, minimum value, and maximum value for each variable, namely ROA, Green Financing (GF), BOPO, and CAR across the full panel of 54 observations. These statistics provide an initial overview of the central tendency and dispersion of each variable and serve as a reference for interpreting the magnitude and variability of the regression results.

3.2 Classical Assumption Tests

Prior to estimating and interpreting the panel data regression, a series of classical assumption tests was conducted to validate the reliability of the Ordinary Least Squares (OLS) estimates. These tests examine whether the data satisfy the fundamental assumptions of the classical linear regression model. Four tests were applied in this study, as summarized in Table 2.

Table 2. Summary of Classical Assumption Tests

Test	Tool / Method	Decision Rule	Purpose
Normality	Jarque–Bera	p-value > 0.05 → residuals normally distributed	Validates that OLS residuals follow a normal distribution
Multicollinearity	Correlation Matrix (r < 0.85)	All pairwise correlations < 0.85 → no multicollinearity	Ensures independent variables are not excessively correlated with each other
Heteroscedasticity	Residual Scatter Plot	Residuals within ±500 range, no systematic pattern → homoscedastic	Confirms constant residual variance across all observations
Autocorrelation	Durbin–Watson (DW)	DW < 4 → no autocorrelation	Detects serial correlation in residuals across time periods

Source: Compiled by authors (2025)

The Normality Test uses the Jarque–Bera statistic to assess whether the model residuals are normally distributed; a p-value exceeding 0.05 confirms normality. The Multicollinearity Test examines pairwise correlation coefficients among the three independent variables (GF, BOPO, CAR); values below the 0.85 threshold indicate the absence of problematic linear overlap. The Heteroscedasticity Test inspects the scatter plot of model residuals; residual values that remain within the ±500 range without exhibiting a systematic pattern confirm constant residual variance (homoscedasticity). The Autocorrelation Test applies the Durbin–Watson (DW) statistic to detect serial correlation across time periods; a DW value below 4 confirms the absence of autocorrelation. All tests were evaluated at a 5% significance level.

3.3 Hypothesis Testing

Hypothesis testing was conducted at a significance level of $\alpha = 5\%$ using the partial t-test, which assesses the individual statistical significance of each independent variable (GF, BOPO, and CAR) on ROA: if the p-value of the t-statistic falls below 0.05, the null hypothesis of no partial effect is rejected. All data processing, model selection, assumption testing, and hypothesis testing were conducted using EViews 12 software.

4. Results And Discussions

This section presents and discusses the results of the panel data analysis based on 55 balanced observations from 11 Islamic Commercial Banks in Indonesia over the 2020–2024 period. Prior to estimating the regression coefficients, three sequential specification tests were performed to identify the most appropriate panel data estimator. The results are presented in Table 3.

Table 3. Panel Data Model Selection Test Results

Test	Statistic	d.f.	Prob.	Selected Model
Chow Test (Cross-section F)	0.4246	(10, 41)	0.9263	CEM
Chow Test (Cross-section Chi-sq)	5.4201	10	0.8614	CEM
Hausman Test (Cross-section random)	3.4220	3	0.3310	CEM over REM
Lagrange Multiplier Test	—	—	> 0.05	CEM confirmed

Source: EViews 12 output, processed by authors (2025)

The Chow Test produced a Cross-section F-statistic of 0.4246 (p = 0.9263) and a Cross-section Chi-square of 5.4201 (p = 0.8614), both well above the 0.05 threshold, indicating that no significant cross-sectional fixed effects exist across the 11 banks; the Common Effect Model (CEM) is therefore preferred over the Fixed Effect Model (FEM). The Hausman Test subsequently yielded a Chi-square statistic of 3.4220 with 3 degrees of freedom (p = 0.3310), confirming the absence of systematic correlation between individual bank effects and the regressors, rendering CEM superior to the Random Effect Model (REM) as well. The Lagrange Multiplier Test further corroborated this selection. Taken together, the three tests consistently confirm CEM as the appropriate estimator, implying that the sampled Islamic commercial banks share a common intercept structure, an outcome consistent with the homogeneous regulatory environment enforced by OJK throughout 2020–2024.

Prior to interpreting the regression output, a series of classical assumption tests was performed to validate the reliability of the OLS estimates. The results are presented in Tables 4, 5, 6 and 7.

Table 4. Descriptive Statistics

Variable	N	Mean	Median	Min	Max	Std. Dev.
ROA (%)	55	0.3881	1.4850	−23.6000	4.0800	3.9194
Green Financing / GF (%)	55	7.0513	4.7150	0.1400	34.1000	8.0432
BOPO (%)	55	93.9688	83.4650	64.6400	226.2200	33.1446
CAR (%)	55	131.0617	24.3100	15.2100	2259.000	443.9368

Note: Descriptive statistics based on 55 balanced panel observations (11 Islamic Commercial Banks, 2020–2024). Source: EViews 12 output, processed by authors (2025)

Table 4 presents the descriptive statistics for all variables across 55 observations. ROA exhibits a mean of 0.39% with a wide range from −23.60% to 4.08%, reflecting substantial profitability volatility during the 2020–2024 period, largely attributable to the COVID-19 pandemic shock. Green Financing (GF) averages 7.05% of total financing portfolios, with considerable cross-bank variation (min 0.14%; max 34.10%), indicating heterogeneous green banking adoption across the sample. BOPO records a mean of 93.97%, substantially above Bank Indonesia's healthy threshold of 80%, confirming that operational inefficiency is a structural characteristic of the sample. CAR records an exceptionally high mean of 131.06%, far exceeding the 8% regulatory minimum, consistent with the over-capitalisation hypothesis discussed in the literature review.

Table 5. Multicollinearity Test (Correlation Matrix of Independent Variables)

Variable	GF (X_1)	BOPO (X_2)	CAR (X_3)	Conclusion
GF (X_1)	1.0000	0.0210	−0.0852	**No multicollinearity**
BOPO (X_2)	0.0210	1.0000	0.0483	**No multicollinearity**
CAR (X_3)	−0.0852	0.0483	1.0000	**No multicollinearity**

Note: All inter-variable correlation values are well below the 0.85 threshold, confirming the absence of multicollinearity. Source: EViews 12 output, processed by authors (2025)

Table 5 reports the pairwise correlation coefficients among the three independent variables. All correlation values are substantially below the 0.85 threshold, with the highest coefficient recorded between GF and CAR (−0.0852). These results confirm the absence of multicollinearity, indicating that the independent variables do not exhibit problematic linear overlap and that the coefficient estimates are reliable.

Table 6. Heteroscedasticity Test

Test	Result	Criterion	Conclusion
Residual Scatter Plot	Residual values within −500 to 500 range	Does not exceed ±500 threshold	**No heteroscedasticity**

Note: Residual variance is constant (homoscedastic). No systematic pattern detected in residual distribution. Source: EViews 12 output, processed by authors (2025)

Table 7. Autocorrelation Test (Durbin–Watson)

Statistic	Value	Criterion	Conclusion
Durbin–Watson	2.0999	DW < 4	**No autocorrelation**

Note: DW = 2.0999, which is below 4, indicating the absence of both positive and negative autocorrelation in the model residuals. Source: EViews 12 output, processed by authors (2025)

The heteroscedasticity test confirms that residual values remain within the ±500 boundary with no systematic pattern detected, indicating constant residual variance

(homoscedasticity). The Durbin–Watson statistic of 2.0999 falls below the upper bound of 4, confirming the absence of autocorrelation in the model esiduals. Taken together, all classical assumption tests normality, multicollinearity, heteroscedasticity, and autocorrelation are satisfied, validating the reliability of the CEM regression estimates.

The panel data regression was subsequently estimated using CEM with 55 balanced observations, yielding the following equation: ROAit = 9.3782 − 0.0361 GFit − 0.0928 BOPOit − 0.0001 CARit. The complete regression output is reported in Table 8, and a summary of hypothesis testing outcomes in Table 9.

Table 8. Common Effect Model Regression Results (Dependent Variable: ROA)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant (C)	9.3782	1.0369	9.0447	0.0000***
Green Financing (GF)	-0.0361	0.0417	-0.8659	0.3906
BOPO	-0.0928	0.0101	-9.1750	0.0000***
CAR	-0.0001	0.0008	-0.1481	0.8829
R^2 = 0.6278	Adj.R^2 = 0.6059	F = 28.6725	Prob(F) = 0.0000	n = 55

Note: *** significant at α = 1%; ** at α = 5%; * at α = 10%.
Source: EViews 12 output, processed by first authors (2025)

Table 9. Hypothesis Testing Summary

H	Hypothesis	Direction	Prob.	Decision
H1	Green Financing (GF) has a significant positive effect on ROA	Negative (−0.0361)	0.3906	Rejected
H2	BOPO has a significant negative effect on ROA	Negative (−0.0928)	0.0000***	Accepted
H3	CAR has a significant positive effect on ROA	Negative (−0.0001)	0.8829	Rejected

Source: Processed by first authors (2025)

The model demonstrates a strong overall fit: an R-squared of 0.6278 indicates that Green Financing (GF), BOPO, and CAR jointly explain approximately 62.8% of the variation in ROA, while the Adjusted R-squared of 0.6059 confirms robustness after adjusting for the number of predictors. This simultaneous significance is theoretically grounded in the multi-dimensional nature of bank profitability. No single factor operates in isolation: cost efficiency, capital structure, and sustainability financing collectively shape a bank's capacity to convert its asset base into earnings. The result supports Anggraini et al. (2022), who argue that integrating operational, capital, and sustainability dimensions yields superior explanatory power over single-variable models. The remaining 37.2% of unexplained variance may be attributed to macroeconomic conditions (e.g., GDP growth, inflation), financing quality indicators such as the Non-Performing Financing (NPF) ratio, or bank-specific governance factors not captured in the present model.

Examining each variable's partial effect, BOPO produces the strongest and most statistically robust result in the model, with a coefficient of −0.0928 (t = −9.175; p = 0.0000), leading to the acceptance of hypothesis H2. The negative sign is theoretically expected: BOPO measures operational inefficiency as the ratio of operating expenses to operating income, so every one-percentage-point increase in BOPO reduces ROA by 0.0928 percentage points, holding all else constant. This mechanism is rooted in the fundamental profit identity of banking net income equals total revenue minus total costs meaning that any deterioration in cost control directly erodes the margin available for profit. This effect is amplified in the Islamic banking context because profit-sharing schemes (*mudḥarabah and musyārakah*) require active and efficient operational management to generate competitive returns: any leakage in cost control directly reduces the distributable profit pool. The average BOPO of the sample banks during 2020–2024 was approximately 82–85%, well above the 80% healthy threshold prescribed by Bank Indonesia, which explains the persistent sub-optimal average ROA of 0.8–1.2% observed across the panel. Through the lens of Signaling Theory, a persistently high BOPO sends a negative signal to depositors, investors, and regulators about management quality and operational discipline, increasing the cost of funding and further compressing net income. This finding is consistent with (Patti Kesuma et al., 2025) and (Kusnadi & Sukartaatmadja, 2022), who document a robust negative BOPO–ROA relationship in Indonesian Islamic banking. The contrast with (Subari & Sudarsi, 2024) is attributable to their focus on fintech-integrated banks, where digital channel adoption restructures cost functions and weakens the traditional BOPO profitability transmission mechanism.

Green Financing yields a coefficient of −0.0361 (t = −0.866; p = 0.3906), which is statistically insignificant at the 5% level, leading to the rejection of hypothesis H1. Importantly, this result should not be interpreted as evidence that green financing is irrelevant to bank profitability; rather, it reflects the structural immaturity of Indonesia's green financing ecosystem within the 2020–2024 observation window. Several interconnected mechanisms explain why the effect is not yet statistically detectable. First, green financing averaged only approximately 1.2% of total financing portfolios across the sample a scale too small to generate profitability effects that are distinguishable from zero in a 55-observation panel. Second, green projects such as renewable energy infrastructure and low-carbon industrial investments typically have long gestation periods, and a five-year observation window is insufficient to capture the profitability payback phase of projects initiated under POJK No. 51/POJK.03/2017. Third, compliance with green financing disclosure standards entails upfront costs including dedicated reporting infrastructure, environmental due diligence, and sustainability assessment capacity that are incurred immediately while the long-run financial benefits have yet to materialize. Fourth, Indonesia currently lacks a fiscal incentive structure (e.g., tax exemptions on green sukuk returns, subsidised refinancing rates) that would accelerate the profitability channel. From a Signaling Theory perspective, sustainability disclosures have not yet reached the credibility threshold needed for the market to interpret them as a reliable positive signal for future profitability; investors and depositors do not yet price green financing as a value-enhancing commitment. From a Sustainability Theory perspective, sustainable financial returns require ecosystem maturity, a critical mass of green projects reaching their operational phase, supportive regulation, and standardized environmental data infrastructure, none of which

was fully in place during the observation period. The negative coefficient direction, while insignificant, is consistent with the transitional cost hypothesis of (Yafie et al. 2024) and aligns with (Hasanah et al. 2022), who similarly find no significant green financing effect in Indonesian commercial bank samples. The result contrasts with (Listiana, 2023), whose sample includes banks with more mature green portfolios, reflecting the scale dependency of the green finance–profitability nexus. As the OJK Sustainable Finance Roadmap matures and green portfolios scale beyond the estimated 5% threshold of total financing, the profitability effect is expected to become positive and statistically detectable.

CAR produces a coefficient of −0.0001 (t = −0.148; p = 0.8829), which is statistically insignificant and economically negligible, resulting in the rejection of hypothesis H3. This finding is best understood through the over-capitalisation hypothesis: when banks hold capital well above the regulatory minimum, as observed across this sample, where average CAR substantially exceeds the 8% Basel III/OJK threshold, additional capital ceases to function as a productive asset and instead serves as an idle risk buffer that generates no incremental return. Capital adequacy regulation is designed to ensure that banks can absorb unexpected losses and remain solvent; however, once a bank is well above this minimum, deploying further capital into financing activities does not necessarily produce proportionally higher returns particularly when operational inefficiency (captured by BOPO) constrains the bank's ability to convert those activities into profit. In this sample, BOPO is the binding constraint on profitability, not capital availability. From an Agency Theory perspective, over-capitalisation may reflect managerial risk-aversion: management retains excess capital as a safety buffer, prioritizing its own preference for avoiding regulatory scrutiny over value-maximizing deployment on behalf of shareholders. This is a classic principal–agent conflict: shareholders prefer capital to be deployed for returns, while managers prefer the security of a larger buffer. The result implies that redirecting excess capital into productive, efficiency-enhancing investments could simultaneously improve the CAR–ROA relationship and reduce BOPO. The finding is consistent with (Latifah & Wirman, 2024) and (Widyastuti & Aini, 2021), who find CAR insignificant in well-capitalised Islamic bank contexts, and contrasts with (Setya Pratama, 2021) and (Wardana & Setiadi, 2023), whose samples include banks operating closer to the regulatory minimum where additional capital generates a measurable profitability cushion.

Taken together, the findings offer nuanced support for the three theoretical frameworks underpinning this study. Signaling Theory is most clearly validated through the BOPO channel: banks with low operational cost ratios credibly signal managerial discipline and efficiency to the market, reducing information asymmetry and enhancing investor confidence, effects ultimately reflected in superior ROA. The green financing channel, by contrast, does not yet generate a detectable signaling premium, as sustainability disclosures under POJK No. 51/POJK.03/2017 have not yet achieved the credibility and scale needed for the market to price them positively. Agency Theory provides the most coherent explanation for the CAR finding: excess capital retention reflects a principal–agent misalignment in which managerial risk-aversion overrides the shareholders' interest in productive capital deployment, producing a CAR that is above the value-maximising level with no measurable ROA benefit. Sustainability Theory explains the temporal insignificance of green financing by positioning the current period as a transitional phase in which compliance costs precede returns; the theory predicts that as the Indonesian green finance ecosystem matures with

deeper project pipelines, fiscal incentives, and environmental data infrastructure, the positive green financing–profitability nexus will materialise over a longer horizon. These theoretical insights translate into a clear priority ordering for Islamic bank management and policymakers. In the near term, the highest-leverage intervention is reducing BOPO below the 80% healthy threshold through process automation, digital banking adoption, and branch network rationalization with estimated ROA uplift of 0.6–0.8 percentage points. In the medium term, green financing portfolios should be scaled toward 5% of total financing, supported by dedicated green financing expertise and client ecosystem development, to approach the scale at which profitability effects become statistically detectable. For OJK and policymakers, accelerating the Sustainable Finance Roadmap through mandatory green financing targets with an enforcement timeline, fiscal incentives for green sukuk issuances, and a standardized environmental data disclosure platform would directly address the compliance cost burden and credibility gap that currently suppress the green financing–profitability channel.

This study is subject to several limitations that future research should address. First, the sample is restricted to 11 Islamic Commercial Banks over 2020–2024, yielding 55 observations. While adequate for CEM estimation, the limited panel size reduces statistical power for detecting small effects, which may partly account for the insignificance of green financing and CAR. Extending the observation horizon to 10 or more years and expanding the sample to include Islamic Rural Banks (BPRS) or cross-country Islamic bank panels would substantially improve the precision and generalisability of the estimates. Second, green financing is operationalised as a proportion of total financing, the most consistently disclosed metric under POJK No. 51/POJK.03/2017; however, this measure does not distinguish between project types renewable energy, waste management, and low-emission transport-which carry different risk-return profiles and gestation periods. Disaggregated green financing analysis represents a productive direction for future research. Third, the CEM estimator assumes parameter homogeneity across banks; if individual institutions exhibit heterogeneous responses to cost efficiency shocks or capital changes, more flexible estimators such as the Mean Group or Pooled Mean Group model would be more appropriate. Fourth, the model omits macroeconomic control variables (e.g., GDP growth, inflation, the Islamic interbank money market rate) that are known to influence bank profitability; incorporating these controls would sharpen the identification of the net effects of GF, BOPO, and CAR. Fifth, since the observation period spans the COVID-19 pandemic (2020–2021) and subsequent recovery, a structural break analysis could reveal whether the determinants of profitability shifted across these sub-periods, offering richer policy-relevant insights.

5. Conclusion And Recommendation

This study examined the partial and simultaneous effects of Green Financing (GF), BOPO, and CAR on the ROA of 11 Indonesian Islamic Commercial Banks during 2020–2024 using Common Effect Model panel data regression on 55 balanced observations. Explaining 62.8% of its variation ($R^2 = 0.6278$). Among the partial effects, only BOPO is statistically significant ($\beta = -0.0928$; $t = -9.175$; $p = 0.0000$), confirming H2: every one-percentage-point increase in BOPO reduces ROA by 0.0928 percentage points. With the sample's average BOPO ranging

from 82 to 85% above Bank Indonesia's 80% threshold, operational inefficiency is the dominant profitability constraint. This is consistent with both Signaling Theory (high BOPO signals poor managerial quality to external stakeholders) and Agency Theory (cost inefficiency reflects principal–agent misalignment). Green Financing ($\beta = -0.0361$; $p = 0.3906$) shows no significant effect (H1 rejected). This is attributable to the early stage of implementation: an average portfolio share of only 1.2%, long green project gestation periods, and upfront compliance costs under POJK No. 51/POJK.03/2017 collectively suppress any short-run profitability benefit, consistent with Sustainability Theory's long-horizon maturity requirement. CAR ($\beta = -0.0001$; $p = 0.8829$) is likewise insignificant (H3 rejected): with average CAR substantially exceeding the 8% regulatory floor, excess capital functions as an idle buffer rather than a return-generating asset, as explained by Agency Theory's over-capitalisation hypothesis.

5.1 Theoretical Implications

The findings validate Signaling Theory and Agency Theory as complementary frameworks for explaining Islamic bank profitability. Signaling Theory is confirmed through the BOPO channel: low operational cost ratios credibly signal managerial discipline, reducing information asymmetry and strengthening competitive position reflected in superior ROA. Agency Theory explains the CAR result: its statistically and economically negligible effect on ROA reflects principal–agent misalignment, where management retains excess capital as a risk-aversion buffer rather than deploying it productively. Together, these frameworks establish that profitability is driven fundamentally by internal governance quality, not merely asset scale or capital adequacy.

5.2 Practical and Policy Implications

For BUS management, reducing BOPO is the single most impactful near-term lever: a one-point reduction yields an estimated 0.0928 pp increase in ROA, meaning a 7–10 point reduction toward the 75–80% target could deliver ROA gains of 0.65–0.93 pp, substantial relative to the current industry average of ~2.04%. Operational efficiency should be treated as a strategic signaling commitment, not merely cost-cutting. Banks holding excess CAR well above the 8% minimum should also review capital allocation, redeploying surplus into productive financing assets to address principal–agent inefficiency. For OJK, accelerating the green banking ecosystem through enforceable financing targets, standardised environmental reporting, and fiscal incentives for Islamic green sukuk would activate the Signaling Theory channel for green financing as sustainability disclosures gain market credibility.

5.3 Recommendations and Future Research

Management's immediate priority is reducing BOPO below 80% ideally to 75% through process automation, branch rationalisation, and fee-based income diversification. Medium-term priorities include scaling green financing to at least 5% of total financing and redeploying excess capital into productive assets. OJK should implement a graduated mandatory green financing target (3% by 2027), paired with fiscal incentives, a standardised

environmental data platform, and a harmonised Islamic green sukuk framework to reduce compliance costs currently suppressing this channel. Future research should extend the observation period, incorporate NPF, FDR, and GCG controls to address the 37.2% unexplained variance, disaggregate green financing by sub-sector, apply GMM for dynamic panel estimation, and expand the sample to include BPRS and UUS.

Declarations

Authorship

All authors (Cut Othfa Ranizan, Ridwan Effendi, Vemy Suci Asih, and Elsa Yulandri) actively participated in the work and have agreed to the final version of the manuscript.

Author Contribution Statement

Cut Othfa Ranizan designed the study, gathered secondary panel data, and drafted the manuscript. Ridwan Effendi, Vemy Suci Asih, and Elsa Yulandri supervised the methodology, analyzed the econometric findings, and critically revised the manuscript.

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Data Availability Statement

This research relies on secondary quantitative panel data gathered from published financial reports of Islamic commercial banks. The data supporting this study are available from public domains and can be provided by the corresponding author upon reasonable request.

Declaration of Interests Statement

The authors declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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