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Operational Efficiency across Bank Size Regimes: Evidence from Indonesian Private Banks

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Abstract

The banking industry is experiencing increasing pressure from digital transformation, intensifying fintech competition, rising operating costs, and changing market conditions, making operational efficiency a critical determinant of sustainable profitability. However, previous studies predominantly assume a linear relationship between operational efficiency and profitability or treat bank size as a constant moderating variable, overlooking the possibility that efficiency effects differ across organizational scales. This study aims to examine the impact of operational efficiency on profitability and investigate whether the relationship varies across bank size regimes among Indonesian private banks. The analysis employs quarterly panel data from 34 Indonesian private banks over the period 2021Q1–2024Q4, comprising 544 bank-quarter observations after applying 2% winsorization. Fixed effects estimation is used as the baseline model, followed by a linear moderation model and a regime-based fixed effects model that distinguishes small, medium, and large banks, with robustness assessed using alternative panel estimators. The findings reveal that A lower BOPO ratio, indicating greater operational efficiency, is associated with higher bank profitability. Nevertheless, the linear moderation model fails to capture size heterogeneity, whereas the regime-based approach demonstrates that The findings reveal a significant relationship between BOPO and bank profitability. While the linear moderation model does not fully capture size-related heterogeneity, the regime-based analysis reveals substantial differences in the magnitude and direction of the BOPO–profitability relationship across small, medium-sized, and large banks. The study contributes by introducing a regime-dependent perspective that integrates Efficiency Structure Theory, Economies of Scale Theory, and Organizational Complexity Theory to explain bank size heterogeneity. Although the analysis is limited to Indonesian private banks, future research may extend this framework to cross-country settings, alternative profitability measures, and dynamic nonlinear panel models.

Keywords: Operational Efficiency, Profitability, Bank Size Regimes, Fixed Effects, Heterogeneity, Indonesian Private Banks

1. Introduction

The global banking industry is currently operating under increasing pressure from persistently high interest rates, rapid digital banking transformation, intensifying competition from financial technology (FinTech), and rising operating costs. These structural changes have altered banks' business models by requiring substantial investment in digital infrastructure while simultaneously demanding greater cost efficiency to sustain profitability (Bueno et

al., 2024; Gržeta et al., 2023). Digital transformation does not automatically improve financial performance because technology investment may initially increase operating costs before generating efficiency gains, making operational efficiency a strategic capability rather than merely an operational objective (Zhang, 2026; Meero, 2025). This issue is particularly relevant in Indonesia, where domestic private banks constitute a substantial segment of the national banking system. According to the Indonesian Financial Services Authority (OJK), domestic private banks held approximately IDR 5,577 trillion in total assets at the end of 2024, representing about 44.8% of the IDR 12,461 trillion total assets of Indonesian commercial banks, highlighting their economically significant role in the banking industry (OJK, 2024). Consequently, operational efficiency has become a critical priority for maintaining long-term competitiveness (Elmahdy et al., 2025; Ebissa & Lakew, 2025). Indonesia reflects this transformation, as private banks face similar pressures while differing substantially in organizational scale, managerial complexity, and resource availability. These differences suggest that banks of different sizes may not generate identical profitability gains from similar improvements in operational efficiency (Gržeta et al., 2023).

Prior banking research has generally examined the relationship between operational efficiency and profitability within a linear framework, implicitly assuming that changes in operational efficiency generate relatively uniform profitability responses across banks. However, this assumption may be restrictive because bank size is associated with differences in organizational structure, operating capacity, cost absorption, and managerial complexity, which can influence how efficiency translates into financial performance (Singh & Thaker, 2020; Bolívar et al., 2022; Gržeta et al., 2023). Although previous studies have incorporated bank size through interaction or moderation terms, such specifications primarily capture whether the efficiency–profitability relationship changes incrementally with size and may therefore be insufficient when small, medium-sized, and large banks operate under structurally different conditions (Singh & Thaker, 2020; Bolívar et al., 2022; Elmahdy et al., 2025). This limitation is particularly relevant because larger banks may benefit from economies of scale while simultaneously facing greater organizational and managerial complexity, whereas smaller banks may encounter higher relative operating costs and more limited resources (Gržeta et al., 2023; Bolívar et al., 2022). Evidence from different banking systems further demonstrates that the effects of bank size on efficiency and profitability are context-dependent, suggesting that size-related heterogeneity cannot necessarily be represented adequately by a single linear relationship (Almaqtari et al., 2019; Gupta & Mahakud, 2020; Elmahdy et al., 2025).

Despite this evidence, limited attention has been given to whether the relationship between operational efficiency and profitability itself differs across distinct bank-size regimes rather than merely changing through a linear interaction with size. This represents an important gap because treating commercial banks as a homogeneous group may conceal structural differences in cost structures, strategic flexibility, operational capacity, and profitability responses across small, medium-sized, and large banks (Bolívar et al., 2022; Gržeta et al., 2023). A regime-based perspective therefore provides a more explicit framework for identifying size-related structural heterogeneity and determining whether operational efficiency is associated with profitability differently across bank-size categories. Accordingly, this study examines whether operational efficiency significantly influences bank profitability, whether this relationship differs across small, medium-sized, and large bank-size regimes, and which bank-size regime exhibits the greatest sensitivity to changes in operational efficiency.

The study contributes to the banking literature by shifting the analytical perspective from conventional linear moderation toward a regime-dependent relationship between operational efficiency and profitability. Previous evidence suggests that bank size does not merely function as a uniform amplifying or weakening factor, as efficiency and profitability relationships may vary across bank-size categories (Gržeta et al., 2023; Singh & Thaker, 2020; Bolívar et al., 2022; Hasan et al., 2020; Elmahdy et al., 2025). The theoretical contribution is structured around Efficiency Structure Theory as the primary mechanism, which explains how greater operational efficiency can enhance bank profitability, while Economies of Scale Theory explains the potential cost advantages associated with increasing operational scale (Blatter & Fuster, 2022; Otero et al., 2020; Gržeta et al., 2023). At larger organizational scales, however, these benefits may be offset by increasing coordination costs, managerial complexity, monitoring difficulties, and agency problems, as explained by Organizational Complexity Theory and Agency Theory (Beccalli & Rossi, 2023; Bolívar et al., 2022; Singh & Thaker, 2020; Mateev et al., 2022). Integrating these theoretical mechanisms provides a basis for understanding why the efficiency–profitability

relationship may differ across small, medium-sized, and large bank regimes rather than following a uniform linear pattern. Beyond its theoretical contribution, the study offers policy and managerial relevance by suggesting that efficiency strategies may need to account for differences in bank scale, organizational structure, and operating conditions (Gržeta et al., 2023; Dávila & Walther, 2020; Moudud-Ul-Huq, 2020; Le et al., 2020; Naseri et al., 2020).

This study addresses the identified gap by examining the relationship between operational efficiency and bank profitability across different bank-size regimes in the Indonesian private banking sector. Rather than assuming that bank size simply strengthens or weakens a uniform efficiency–profitability relationship, the study recognizes that small, medium-sized, and large banks may operate under different cost structures, organizational capacities, and levels of managerial complexity. By combining a baseline fixed-effects model, a conventional linear moderation model, and a regime-based analysis, the study provides a framework for identifying whether the relationship between operational efficiency and profitability varies structurally across bank sizes. The novelty of this study lies in treating bank size as a source of structural heterogeneity that generates distinct efficiency–profitability regimes rather than as a conventional linear moderator.

2. Literature Review and Hypothesis Development

2.1 Operational Efficiency

Operational efficiency, as reflected by BOPO, represents the extent to which operating income is absorbed by operating expenses, with a lower BOPO indicating greater cost efficiency. Prior evidence shows that higher operating costs generally reduce profitability, suggesting that effective cost control is essential for improving bank financial performance (Fadhilah et al., 2025; Amrih, 2026). Cost efficiency also reflects managerial efficiency because managers are responsible for allocating resources, controlling operating expenses, and ensuring that banking activities generate sufficient income relative to their costs (Fadhilah et al., 2025; Hani et al., 2025). From an agency perspective, inefficient cost structures may indicate higher agency costs arising from weak monitoring and managerial discretion over resource allocation (Gržeta et al., 2023; Adrian, 2025). This argument is complemented by X-efficiency theory, which suggests that banks operating under similar market conditions may achieve different performance outcomes because they differ in their ability to utilize inputs efficiently and convert resources into productive outputs (Gržeta et al., 2023; Adrian, 2025). Accordingly, BOPO captures more than an accounting relationship between operating expenses and operating income; it reflects differences in cost control, managerial efficiency, and productive resource utilization that ultimately contribute to variations in bank profitability across institutions and over time (Fadhilah et al., 2025; Hani et al., 2025; Jatmiko, 2025).

Operational efficiency reflects a bank's ability to manage operating resources and costs effectively in generating operating income. In the Indonesian banking context, operational efficiency is commonly measured using the ratio of Operating Expenses to Operating Income (BOPO), which captures the proportion of operating income absorbed by operating expenses. Because BOPO is an inverse indicator of operational efficiency, a lower ratio represents greater efficiency, whereas a higher ratio indicates greater operating cost pressure and, consequently, lower operational efficiency (Almaqtari et al., 2019; Mateev et al., 2022; Gržeta et al., 2023). From the Efficiency Structure perspective, banks that utilize their resources more efficiently are expected to achieve stronger financial performance because effective cost management allows a greater proportion of operating income to be translated into profits (Mateev et al., 2022; Gržeta et al., 2023). Accordingly, a negative relationship between BOPO and profitability is theoretically expected, indicating that reductions in BOPO, rather than increases in the ratio, represent improvements in operational efficiency.

2.2 Profitability

ROA is widely used as the main profitability indicator in banking because it measures how effectively a bank converts its asset base into earnings. In the literature, ROA is preferred over many alternative accounting measures because banks are asset-intensive institutions, so asset utilization better reflects managerial performance and operational effectiveness than sales-based profitability metrics used in non-financial firms (Sukmadewi, 2020;

Karamoy & Tulung, 2020). Prior studies also show that ROA responds clearly to internal banking drivers such as BOPO, liquidity, capital adequacy, and asset management, which makes it especially suitable for testing the profitability effects of operational efficiency in banks (Abdelmoneim & Yasser, 2023; Wahyuni & Umam, 2023). Therefore, this study adopts ROA as the dependent variable because it provides a direct, comparable, and theoretically grounded measure of banking profitability across institutions, ownership types, and size categories. Compared with Return on Equity (ROE), which is more sensitive to differences in leverage and capital structure, ROA provides a more appropriate measure of banks' ability to generate earnings from their asset base and therefore better reflects operational performance across banks with different capitalization levels (Karamoy & Tulung, 2020; Yuan et al., 2022).

2.3 Bank Size, Economies of Scale, and Organizational Complexity

Bank size can generate structural differences in the relationship between operational efficiency and profitability because banks at different scales face distinct opportunities and constraints in managing operating costs. Small banks generally have greater room for cost optimization, as improvements in resource allocation, process efficiency, and operating cost control can generate relatively substantial profitability gains from a comparatively limited operational base (Blatter & Fuster, 2022; Grzeta et al., 2023). As banks expand toward medium scale, economies of scale allow fixed costs to be distributed across a broader asset and operating base, enabling them to approach a more efficient scale at which the benefits of additional cost reductions become more stable (Blatter & Fuster, 2022; Grzeta et al., 2023). At larger scales, however, increasing organizational complexity, bureaucratic layers, coordination requirements, regulatory burdens, and agency costs may introduce diseconomies that weaken the extent to which improvements in operational efficiency translate into higher profitability (Mateev et al., 2022; Le et al., 2020; Tan et al., 2021). These mechanisms imply that the BOPO–profitability slope may differ across small, medium-sized, and large banks, providing a theoretical basis for treating bank size as structural heterogeneity and examining the efficiency–profitability relationship through distinct bank-size regimes rather than assuming a single linear effect across all banks.

2.4 Agency Theory

Agency Theory explains the relationship between principals and agents when ownership and managerial control are separated, creating potential conflicts of interest due to differences in objectives and information asymmetry (Jensen & Meckling, 1976). In banking institutions, agency problems may arise between shareholders, managers, depositors, and other stakeholders because managers possess greater information about operational decisions, risk-taking, and resource allocation than external parties. Effective governance mechanisms are therefore required to monitor managerial behavior, reduce opportunistic actions, and align management decisions with organizational objectives (Fama & Jensen, 1983; Eisenhardt, 1989). From this perspective, operational efficiency reflects management's ability to control costs and utilize resources effectively, while persistent inefficiency may indicate weak monitoring or managerial agency costs. Bank size can further influence these agency problems because larger banks tend to have more complex organizational structures, broader managerial hierarchies, and higher monitoring costs, which may affect the relationship between operational efficiency and profitability (Jensen & Meckling, 1976; Eisenhardt, 1989). Accordingly, increasing organizational scale may raise monitoring and agency costs, weakening the extent to which reductions in BOPO translate into higher profitability.

2.5 Hypotheses

Operational efficiency is widely recognized as one of the primary determinants of bank profitability because it reflects management's ability to control operating costs while generating sustainable income. According to the Efficiency Structure Theory, banks that utilize resources more efficiently can achieve stronger competitive advantages and higher financial performance, whereas higher operating costs relative to operating income reduce profitability by eroding the returns generated from productive assets (Berger & Mester, 1997; Mateev et al., 2022). Recent empirical evidence consistently demonstrates that cost inefficiency, commonly measured by the cost-to-income ratio or BOPO, exerts a significant negative effect on return on assets across both developed and emerging banking systems, highlighting the importance of effective cost management in maintaining profitability (Grzeta et

al., 2023; Karamoy & Tulung, 2020; Yuan et al., 2022; Ullah et al., 2023). Therefore, this study proposes that improvements in operational efficiency are expected to enhance bank profitability, leading to the following hypothesis: **H1: A higher BOPO ratio negatively affects bank profitability.**

Although operational efficiency is generally expected to improve bank profitability, its magnitude is unlikely to be identical across banks with different organizational scales. Theories of economies of scale and organizational complexity suggest that small banks tend to experience larger marginal gains from efficiency improvements because of lean organizational structures, whereas medium-sized banks may operate near the optimal scale, and large banks often face diminishing returns due to bureaucratic complexity, coordination costs, and agency problems (Blatter & Fuster, 2022; Gržeta et al., 2023). Recent empirical studies further demonstrate that bank size shapes the relationship between efficiency and financial performance by creating heterogeneous responses across institutions, indicating that the efficiency-profitability nexus cannot be adequately explained by a single linear coefficient (Mateev et al., 2022; Le et al., 2020; Tan et al., 2021; Ullah et al., 2023). Therefore, this study proposes that the impact of operational efficiency varies systematically across bank size regimes, leading to the following hypothesis: **H2: The effect of BOPO on profitability differs significantly across bank size regimes.**

The marginal effect of operational efficiency is expected to be greatest among small banks because their relatively simple organizational structures enable cost reductions to be translated more directly into profitability improvements. According to the Economies of Scale and Organizational Complexity perspectives, small banks still operate below or near the optimal scale, allowing efficiency gains to generate larger improvements in financial performance, whereas larger banks experience increasing coordination costs, bureaucratic layers, and agency problems that reduce the incremental benefit of additional efficiency (Blatter & Fuster, 2022; Gržeta et al., 2023). Empirical evidence also indicates that the profitability response to efficiency enhancement varies with bank size, with smaller institutions often exhibiting stronger efficiency gains because they have greater potential to optimize operating costs and resource allocation than their larger counterparts (Le et al., 2020; Mateev et al., 2022; Abdulahi et al., 2023; Tan et al., 2021). Therefore, this study argues that the strongest profitability response to operational efficiency will be observed among small private banks, leading to the following hypothesis: **H3: The negative effect of BOPO on profitability is strongest among small banks.**

As bank size increases, the positive contribution of operational efficiency to profitability is expected to gradually decline because larger organizations face greater structural and managerial complexity. While economies of scale initially allow banks to lower average operating costs and improve financial performance, these benefits tend to diminish once organizational expansion introduces higher coordination costs, bureaucratic procedures, and agency conflicts that weaken managerial effectiveness (Blatter & Fuster, 2022; Gržeta et al., 2023). Empirical evidence from both developed and emerging banking markets indicates that large banks often experience smaller marginal profitability gains from efficiency improvements than small and medium-sized institutions, as organizational complexity offsets part of the efficiency advantage (Le et al., 2020; Mateev et al., 2022; Tan et al., 2021; Ullah et al., 2023). Therefore, this study proposes that the profitability-enhancing effect of operational efficiency diminishes progressively as bank size increases, leading to the following hypothesis: **H4: The absolute magnitude of the negative BOPO-profitability relationship decreases as bank size increases.**

3. Methodology

3.1 Sample & Data

This study employs a balanced quarterly panel dataset comprising 34 banks observed over 16 quarters of Indonesian private commercial banks basis from the first quarter of 2021 to the fourth quarter of 2024. Quarterly financial data are collected from publicly available financial statements, annual reports, and regulatory disclosures published by the Indonesian Financial Services Authority (Otoritas Jasa Keuangan, OJK), ensuring consistency, transparency, and comparability of bank-level observations over time (Gržeta et al., 2023; Mateev et al., 2022). The use of quarterly panel data is appropriate for banking studies because it captures short-term changes in operational efficiency and profitability while allowing researchers to control for unobserved bank-specific heterogeneity and macroeconomic fluctuations through panel estimation techniques (Tan et al., 2021; Ullah et al.,

2023; Yuan et al., 2022). Similar data sources and panel structures have been widely adopted in recent international banking literature to examine the determinants of profitability, efficiency, and bank performance, supporting the reliability of the present research design (Le et al., 2020; Abdulahi et al., 2023). The sample-selection process began with the population of Indonesian conventional banks, was restricted to private conventional banks with complete quarterly financial data for the 2021–2024 period, excluded banks with incomplete or unavailable observations, and resulted in a final sample of 34 banks comprising 544 bank-quarter observations.

3.2 Variable

The study employs ROA as the dependent variable, BOPO as the main explanatory variable, and CAR, NPL, LDR, and SIZE as control variables. The definitions, measurements, expected relationships with profitability, and data sources for all variables are summarized in Table 1.

Variable	Symbol	Formula/Measurement	Expected Sign	Data Source
Return on Assets	ROA	Net Profit / Total Assets $\times$ 100%	Dependent variable	OJK / Bank Financial Reports
Operating Expenses to Operating Income	BOPO	Operating Expenses / Operating Income $\times$ 100%	–	OJK / Bank Financial Reports
Capital Adequacy Ratio	CAR	Capital / Risk-Weighted Assets $\times$ 100%	+	OJK / Bank Financial Reports
Non-Performing Loan Ratio	NPL	Non-Performing Loans / Total Loans $\times$ 100%	–	OJK / Bank Financial Reports
Loan-to-Deposit Ratio	LDR	Total Loans / Third-Party Funds $\times$ 100%	+/-	OJK / Bank Financial Reports
Bank Size	SIZE	Natural logarithm of total assets, $\ln(\text{Total Assets})$	+/-	OJK / Bank Financial Reports

Note: BOPO is an inverse measure of operational efficiency; therefore, a lower BOPO indicates greater operational efficiency. The expected signs indicate the theoretically anticipated relationships with ROA. A positive or negative sign is specified for LDR and SIZE because their relationships with profitability may vary depending on liquidity conditions, scale benefits, and organizational complexity

This study employs Return on Assets (ROA) as the dependent variable to measure bank profitability because it reflects management's effectiveness in utilizing total assets to generate earnings, a widely accepted approach in banking research. Operational efficiency is represented by the Operating Expense to Operating Income ratio (BOPO), while the Capital Adequacy Ratio (CAR), Non-Performing Loans (NPL), Loan-to-Deposit Ratio (LDR), and bank size (SIZE) are included as control variables to account for capital strength, credit risk, liquidity management, and organizational scale that may influence profitability (Yuan et al., 2022; Mateev et al., 2022; Ullah et al., 2023). To reduce the influence of extreme observations, the continuous variables were winsorized at the 2nd and 98th percentiles prior to estimation. To capture structural heterogeneity, bank-size regimes were subsequently determined using each bank's average winsorized SIZE over the 2021–2024 sample period. The resulting bank-level average SIZE values were divided into terciles, with banks at or below the 33.3rd percentile (P33.3) classified as small, those above P33.3 and at or below the 66.7th percentile (P66.7) classified as medium-sized, and those above P66.7 classified as large (Gržeta et al., 2023; Blatter & Fuster, 2022; Le et al., 2020). Once classified, each bank remained in the same size regime throughout the sample period, enabling the study to examine whether the relationship between BOPO and profitability differs systematically across structurally distinct bank-size regimes rather than assuming a homogeneous relationship across all banks (Le et al., 2020; Tan et al., 2021).

3.3 Economic Models

Before estimating the main regression models, a series of panel model-selection tests was conducted to determine the most appropriate estimator for the data. The Chow/F-test was first employed to compare the pooled ordinary least squares (Pooled OLS) model with the fixed-effects (FE) model, where rejection of the null hypothesis indicates the presence of significant bank-specific effects and supports FE over Pooled OLS. The Breusch–Pagan

Lagrange Multiplier (LM) test was subsequently used to compare Pooled OLS with the random-effects (RE) model, with rejection of the null hypothesis indicating that panel-level variance is statistically relevant and that RE is preferable to pooled estimation. Finally, the Hausman specification test was applied to distinguish between FE and RE by examining whether the unobserved bank-specific effects are systematically correlated with the explanatory variables; rejection of the null hypothesis supports the FE estimator because RE would otherwise produce inconsistent estimates (Hausman, 1978; Baltagi, 2021; Wooldridge, 2010).

The model-selection procedure supported the use of the fixed-effects estimator as the primary specification for the subsequent empirical analysis. Following model selection, diagnostic tests were conducted to assess potential violations of the classical panel-data assumptions, particularly heteroskedasticity, serial correlation, and cross-sectional dependence. Because these disturbances can lead to biased conventional standard errors even when the FE coefficient estimates remain consistent, the main estimates are complemented by robust inference procedures. In particular, Driscoll–Kraay standard errors are employed to provide inference robust to heteroskedasticity, serial correlation, and general forms of cross-sectional dependence, while PCSE and FGLS are used as additional robustness specifications to assess the stability of the estimated relationships under alternative treatments of the panel error structure (Driscoll & Kraay, 1998; Beck & Katz, 1995; Wooldridge, 2010).

3.4 Econometric Models

3.4.1 Model 1 : Baseline Fixed Effects Model

$$ROA_{it} = \beta_0 + \beta_1 BOPO_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 LDR_{it} + \beta_5 SIZE_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

Where:

ROA_{it} = Return on Assets of bank i in quarter t

$BOPO_{it}$ = Operational efficiency (Operating Expenses / Operating Income)

CAR_{it} = Capital Adequacy Ratio

NPL_{it} = Non-Performing Loan ratio

LDR_{it} = Loan to Deposit Ratio

$SIZE_{it}$ = Bank size (natural logarithm of total assets)

α_i = Bank fixed effects

λ_t = Time fixed effects

ε_{it} = Error term

$i = 1, 2, \dots, N$ banks; $t = 1, 2, \dots, T$ quarters

3.4.2 Model 2 : Linear Moderation Model (Interaction Approach)

Model 2 is specified as a benchmark to examine whether bank-size heterogeneity can be adequately captured by a continuous linear interaction between operational efficiency (BOPO) and bank size (SIZE). The model extends the baseline fixed-effects specification by including the $BOPO \times SIZE$ interaction term, thereby testing whether the marginal effect of BOPO on profitability changes linearly as bank size increases.

$$ROA_{it} = \beta_0 + \beta_1 BOPO_{it} + \beta_2 SIZE_{it} + \beta_3 (BOPO_{it} \times SIZE_{it}) + \beta_4 CAR_{it} + \beta_5 NPL_{it} + \beta_6 LDR_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

$$\partial ROA_{it} / \partial BOPO_{it} = \beta_1 + \beta_3 SIZE_{it}$$

Where:

ROA_{it} = Return on Assets of bank i in quarter t

$BOPO_{it}$ = Operational efficiency (Operating Expenses / Operating Income)

$SIZE_{it}$ = Bank size (natural logarithm of total assets)

$BOPO_{it} \times SIZE_{it}$ = Interaction term

CAR_{it} = Capital Adequacy Ratio

NPL_{it} = Non-Performing Loan ratio

LDR_{it} = Loan to Deposit Ratio

α_i = Bank fixed effects

λ_t = Time fixed effects

ε_{it} = Error term

Accordingly, β_3 indicates whether the BOPO–profitability relationship systematically strengthens or weakens along a continuous bank-size scale. However, this specification imposes a linear restriction on size heterogeneity, meaning that the marginal effect is assumed to change smoothly and proportionally with SIZE. Model 3 therefore relaxes this restriction by estimating regime-specific slopes for small, medium-sized, and large banks, allowing the BOPO–profitability relationship to differ structurally across bank-size regimes. Thus, Model 2 serves as a linear moderation benchmark, whereas Model 3 provides the main test of structural heterogeneity.

The purpose of Model 2 is not to replace the regime-based analysis, but to provide a direct comparison between the conventional linear moderation approach and the structural regime approach. If the interaction term captures the heterogeneity adequately, the relationship should be represented by a continuously changing slope. If meaningful differences emerge across the regime-specific estimates in Model 3, this indicates that a single linear interaction may mask structural differences among small, medium-sized, and large banks.

3.4.3 Model 3 : Heterogeneity Fixed Effects Model (Bank Size Regimes)

Regime Fixed Effects Model:

$$ROA_{it} = \beta_0^{(r)} + \beta_1^{(r)} BOPO_{it} + \beta_2^{(r)} CAR_{it} + \beta_3^{(r)} NPL_{it} + \beta_4^{(r)} LDR_{it} + \alpha_i^{(r)} + \lambda_t + \varepsilon_{it}$$

Where:

ROA_{it} = Return on Assets of bank i in quarter t

$BOPO_{it}$ = Operational efficiency (Operating Expenses / Operating Income)

CAR_{it} = Capital Adequacy Ratio

NPL_{it} = Non-Performing Loan ratio

LDR_{it} = Loan to Deposit Ratio

$SIZE_{it}$ = Bank size (natural logarithm of total assets)

$\alpha_i^{(r)}$ = Bank fixed effects within regime r

λ_t = Time fixed effects (common across regimes)

ε_{it} = Error term

Notes:

- Each bank is assigned to one size regime based on the average SIZE over the sample period.
- τ_1 and τ_2 are the threshold values (e.g., determined by tertiles or relevant percentiles of SIZE).
- The slope coefficients $\beta_1^{(r)}, \beta_2^{(r)}, \beta_3^{(r)}, \beta_4^{(r)}$ are allowed to differ across regimes.

Bank-Size Classification

Bank-size regimes are determined using each bank's average winsorized SIZE over the 2021–2024 sample period, defined as:

$$SIZE_{it} = (1/T_i) \sum_{t=1}^{T_i} SIZE_{it}^W$$

Banks are subsequently classified into tertiles as follows:

Bank-Size Regime Classification Criterion :

Small = $SIZ\bar{E}_i \leq P33.3$

Medium = $P33.3 < SIZ\bar{E}_i \leq P66.7$

Large = $SIZ\bar{E}_i > P66.7$

Bank-size regimes are determined from each bank's average winsorized SIZE over the sample period and divided into tertiles using the 33.3rd and 66.7th percentiles. Once classified, each bank remains in the same size regime throughout the sample period, reflecting the treatment of bank size as a structural source of heterogeneity. This specification allows the regime-specific coefficient $\beta_1^{(r)}$ to capture differences in the BOPO–profitability relationship across small, medium-sized, and large banks.

Objective:

To examine whether the impact of operational efficiency (BOPO) and other financial fundamentals on profitability (ROA) differs systematically across small, medium, and large private banks.

3.4.4 Robustness Models

To assess the robustness of the baseline fixed-effects estimates, the study prioritizes alternative inference procedures that address the error structure of the panel data. The baseline coefficients are first estimated using bank fixed effects with bank-clustered robust standard errors. Driscoll-Kraay standard errors and Panel-Corrected Standard Errors (PCSE) are then employed as complementary robustness checks. Panel quantile regression is used as an additional analysis when distributional heterogeneity in profitability provides meaningful insight. FGLS and System GMM are not treated as routine robustness estimators and are retained only when diagnostic evidence provides a clear econometric justification.

Fixed Effects with Bank-Clustered Robust Standard Errors (FE-Cluster)

$$ROA_{it} = \beta_0 + \beta_1 BOPO_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 LDR_{it} + \beta_5 SIZE_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

The coefficient specification follows the baseline fixed-effects model, while standard errors are clustered at the bank level to allow for heteroskedasticity and within-bank serial correlation.

Fixed Effects with Driscoll-Kraay Standard Errors (FE-DK)

$$ROA_{it} = \beta_0 + \beta_1 BOPO_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 LDR_{it} + \beta_5 SIZE_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

The baseline FE coefficients are retained, but inference is based on Driscoll-Kraay standard errors, which are robust to heteroskedasticity, serial correlation, and cross-sectional dependence.

Panel-Corrected Standard Errors (PCSE)

$$ROA_{it} = X_{it}'\beta + \alpha_i + \lambda_t + \varepsilon_{it}$$

PCSE provides an additional check on coefficient inference under contemporaneous correlation and panel-level heteroskedasticity. The sign, magnitude, and statistical significance of the BOPO coefficient are compared with the baseline FE results.

Panel Quantile Regression (Additional Distributional Robustness)

$$Q\tau(ROA_{it} | X_{it}) = X_{it}'\beta_\tau, \tau \in \{0.25, 0.50, 0.75\}$$

Quantile regression evaluates whether the BOPO-profitability relationship differs across lower, median, and upper profitability levels. It is included when such distributional heterogeneity adds substantive insight beyond mean-based estimators.

Conditional estimators. FGLS and System GMM are applied only when supported by diagnostic evidence. FGLS may be considered when the estimated panel error structure requires explicit modelling of heteroskedasticity and serial correlation, whereas System GMM is appropriate only when a dynamic specification and endogeneity concerns are theoretically and empirically justified. They are therefore not part of the core robustness sequence.

4. Result

4.1 Descriptive Statistics

The descriptive statistics provide an overview of the central tendency, dispersion, and distribution of the variables used in this study after applying the 2% winsorization procedure to mitigate the influence of extreme observations. The final dataset consists of 544 bank-quarter observations from 34 Indonesian private banks covering the period from 2021Q1 to 2024Q4.

Table 1: Table Descriptive Statistics of Variables (After 2% Winsorization)

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
ROA	544	1.769	1.834	0.02	10.25
BOPO	544	89.482	30.341	31.05	237.74
CAR	544	40.808	34.734	10.78	206.65
NPL	544	3.041	2.301	0	10.66
LDR	544	92.702	49.534	0.77	355
SIZE	544	17.412	1.407	14.184	21.064

The descriptive statistics indicate considerable heterogeneity among Indonesian private banks despite the application of winsorization to reduce the influence of outliers. The average profitability (ROA) of 1.769% suggests that the sampled banks generated relatively modest returns on assets during the observation period, whereas the mean BOPO of 89.482 indicates that operating expenses remained relatively high compared with operating income, reflecting persistent efficiency challenges. Capital adequacy remained strong, with an average CAR of 40.808%, while the average NPL ratio of 3.041% suggests that credit risk was generally maintained within an acceptable range. In addition, the substantial variation in LDR and SIZE demonstrates meaningful differences in liquidity management and organizational scale across banks, providing a strong empirical basis for investigating heterogeneous profitability effects across small, medium, and large bank size regimes.

4.2 Correlation Analysis

The Pearson correlation matrix is presented to examine the direction and strength of the bivariate relationships among the study variables before conducting multivariate regression analysis. In addition, the correlation matrix provides an initial assessment of potential multicollinearity among the explanatory variables.

Table 2: Table Pearson Correlation Matrix

Variables	ROA	BOPO	CAR	NPL	LDR	SIZE
ROA	1					
BOPO	-0.9573*	1				
CAR	0.3333*	-0.3716*	1			
NPL	-0.4215*	0.3830*	-0.1733*	1		
LDR	0.1414	-0.0831	0.0869	-0.1325	1	
SIZE	0.1886*	-0.1876*	-0.4528*	0.2207*	0.2524*	1

Notes: ** $p < 0.01$; * $p < 0.05$. Pearson correlation coefficients

The correlation analysis reveals that operational efficiency (BOPO) exhibits the strongest relationship with profitability, showing a highly significant negative correlation with ROA ($r = -0.9573$, $p < 0.01$), indicating that banks with lower operating costs relative to operating income tend to achieve substantially higher profitability. Capital adequacy (CAR) is positively associated with ROA ($r = 0.3333$), whereas credit risk (NPL) is negatively related to profitability ($r = -0.4215$), suggesting that stronger capitalization is positively correlated/associated with financial performance while deteriorating asset quality reduces profitability. Liquidity (LDR) demonstrates a weak positive correlation with ROA ($r = 0.1414$), and bank size (SIZE) also exhibits a modest positive association with profitability ($r = 0.1886$), implying that larger banks tend to generate slightly higher returns on assets. Furthermore, the correlations among the independent variables remain well below the conventional threshold of 0.80, indicating that multicollinearity is unlikely to pose a serious concern in the subsequent panel regression analysis.

4.3 Multicollinearity Test

The multicollinearity test was conducted using the Variance Inflation Factor (VIF) to determine whether high correlations existed among the explanatory variables prior to panel estimation. Following the conventional criterion, a VIF value below 10 indicates that multicollinearity is unlikely to bias the regression estimate.

Table 3: Table Variance Inflation Factor (VIF) Results

Variable	VIF	Tolerance (1/VIF)
SIZE	2.14	0.4665
CAR	1.97	0.507
BOPO	1.92	0.522
NPL	1.46	0.6846
LDR	1.23	0.8147
Mean VIF	1.74	-

The VIF results indicate that all explanatory variables exhibit values substantially below the conventional all VIF values are below 5, with individual VIF values ranging from 1.23 to 2.14 and a mean VIF of 1.74. These findings suggest that the independent variables do not share excessive linear dependence and that each contributes unique explanatory information to the empirical model. Among the explanatory variables, **SIZE** records the highest VIF (2.14), followed by **CAR** (1.97) and **BOPO** (1.92), although these values remain well within the acceptable range and therefore do not indicate multicollinearity concerns. Overall, the diagnostic results confirm that multicollinearity is not a threat to the reliability of the estimated coefficients, allowing the subsequent fixed effects and heterogeneity analyses to be interpreted with confidence.

4.4 Baseline Regression

The baseline regression estimates the direct effect of operational efficiency and bank-specific financial characteristics on profitability using the fixed effects estimator. The fixed effects model controls for unobservable time-invariant bank characteristics, allowing the estimated coefficients to reflect within-bank variations over the observation period.

Table 4: Table Baseline Fixed Effects Regression Results

Variables	Coefficient	Robust Std. Error	t-statistic	p-value
CAR	0.003459	0.005776	0.60	0.553
GCG	-0.682286	0.511557	-1.33	0.191
NPL	-0.141490*	0.075538	-1.87	0.070
LDR	0.009661	0.005892	1.64	0.111
BOPO	0.046208*	0.007118	6.49	<0.001
Constant	-1.607334	1.493603	-1.08	0.290
Observations	544			
Number of Banks	34			
Within R²	0.5489			
F-statistic	9.65*			<0.001

Notes: Dependent variable = ROA. Fixed Effects estimation. Robust standard errors where applicable.

The baseline fixed-effects model with bank-clustered robust standard errors shows that BOPO has a positive and statistically significant relationship with ROA ($\beta = 0.046208$, $p < 0.001$), whereas CAR, GCG, and LDR are statistically insignificant at conventional levels. NPL has a negative coefficient ($\beta = -0.141490$) and is weakly significant at the 10% level ($p = 0.070$), indicating limited evidence of a negative relationship between credit risk and profitability. The model is jointly significant ($F = 9.65$, $p < 0.001$) and explains approximately 54.89% of the within-bank variation in ROA. Importantly, because BOPO is an inverse measure of operational efficiency, its positive coefficient indicates that higher operating expenses relative to operating income are associated with higher ROA in this specification; therefore, this result does not support the theoretically expected negative BOPO–ROA relationship and requires careful discussion rather than being interpreted as evidence that greater operational efficiency increases profitability.

4.5 Regime Regression

To examine whether the effect of operational efficiency differs across bank size categories, this study estimates a regime-specific fixed effects model by interacting BOPO with three bank size regimes: small, medium, and large banks. This approach allows the marginal effect of operational efficiency on profitability to vary across organizational scales rather than imposing a single homogeneous coefficient for all banks.

Table 5: Table Fixed Effects Regression across Bank Size Regimes

Variables	Coefficient	Std. Error	t-value	p-value
BOPO effect: Small Banks	0.0300*	0.0035	8.52	0
BOPO effect: Medium Banks	0.0537*	0.0042	5.64	0
BOPO effect: Large Banks	-0.0446*	0.0138	-5.41	0
NPL	-0.1358***	0.0446	-3.04	0.002
Medium $\times$ NPL	-0.0177	0.0578	-0.31	0.76
Large $\times$ NPL	0.1065	0.1591	0.67	0.503
LDR	0.0109***	0.0015	7.22	0
Medium $\times$ LDR	-0.0096***	0.0035	-2.72	0.007
Large $\times$ LDR	-0.0081	0.0067	-1.21	0.228
Constant	-2.3816***	0.7612	-3.13	0.002
Model Statistics	Value			
Observations	544			
Number of Banks	34			
Sigma_u	1.2506			
Sigma_e	0.7496			
Rho	0.7357			
F-test (33,493)	36.17***			

Notes: ***p < 0.01. Small banks constitute the reference category. The reported BOPO effects for medium and large banks are derived from the baseline BOPO coefficient plus the corresponding interaction coefficient. Standard errors, t-statistics, and p-values for these marginal effects must be obtained from post-estimation linear-combination tests rather than copied from the interaction coefficients.

The regime-specific results indicate substantial heterogeneity in the relationship between BOPO and bank profitability. The estimated BOPO effect is positive for small banks ($\beta = 0.0300$) and increases to 0.0537 for medium-sized banks, whereas it becomes negative for large banks ($\beta = -0.0446$), demonstrating a change in both the magnitude and direction of the BOPO–ROA relationship across bank size regimes. This pattern provides evidence of structural heterogeneity, but it does not support the proposed monotonic pattern in which the negative BOPO effect is strongest for small banks and progressively weakens as bank size increases. Therefore, based on the coefficients currently reported, the appropriate conclusion is that bank size changes the nature of the BOPO–profitability relationship, while H3 and H4 concerning the predicted Small $\rightarrow$ Medium $\rightarrow$ Large ordering should not be accepted unless a separate split-sample estimation or correctly calculated marginal effects produces that pattern.

4.6 Robustness Analysis

To assess the reliability of the main findings, this study estimates several alternative model specifications using different panel estimators. Comparing the coefficient estimates across these approaches enables the evaluation of whether the relationship between operational efficiency and profitability remains robust under different assumptions regarding the error structure and conditional distribution of the dependent variable.

Table 6: Table Robustness Analysis

Variables	Coefficient	Driscoll–Kraay Std. Error	t-statistic	p-value	Result
CAR	0.003459	0.002369	1.46	0.165	Not significant
GCG	−0.682286**	0.288893	−2.36	0.032	Significant
NPL	−0.141490***	0.043467	−3.26	0.005	Significant
LDR	0.009661**	0.003986	2.42	0.028	Significant
BOPO	0.046208*	0.005608	8.24	<0.001	Significant
Constant	−1.607334	0.931660	−1.73	0.105	Not significant
Model Statistics					
F(5,15)	36.56			<0.001	Model significant
Within R ²	0.5489				54.89%
Maximum lag	2				

Notes: Dependent variable = ROA. Driscoll–Kraay standard errors are used to account for heteroskedasticity, serial correlation, and cross-sectional dependence. Maximum lag = 2. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively..

The Driscoll–Kraay robustness results show that the model remains jointly significant ($F = 36.56$, $p < 0.001$), with a within R^2 of 0.5489, indicating that approximately 54.89% of the within-bank variation in profitability is explained by the included variables. BOPO remains statistically significant ($\beta = 0.046208$, $p < 0.001$), while NPL has a significant negative association with ROA ($\beta = -0.141490$, $p = 0.005$), LDR has a significant positive association ($\beta = 0.009661$, $p = 0.028$), and CAR is statistically insignificant ($p = 0.165$). The BOPO coefficient remains negative and statistically significant across, however, is positive, meaning that a higher BOPO ratio is associated with higher ROA in this specification; because a higher BOPO represents lower operational efficiency, this result does not support the theoretically expected negative BOPO–ROA relationship. Therefore, the Driscoll–Kraay result should not be described simply as confirming that greater operational efficiency improves profitability; instead, it indicates that the statistical significance of BOPO is robust, while its positive direction requires further explanation and comparison with the baseline and regime-specific estimates.

5. Discussion

5.1 Operational Efficiency and Bank Profitability

The negative effect of the BOPO ratio on ROA is consistent with the Efficiency Structure Theory, which argues that banks achieving superior cost efficiency are more capable of transforming operating resources into sustainable profits than less efficient competitors. A higher BOPO ratio indicates that operating expenses consume a larger proportion of operating income, thereby reducing the bank's capacity to generate returns from its asset portfolio and weakening overall financial performance (Tan et al., 2021; Mateev et al., 2022). This finding is also supported by recent empirical evidence showing that efficient cost management strengthens profitability by improving resource allocation, enhancing managerial effectiveness, and minimizing operational inefficiencies, particularly in increasingly competitive banking markets (Gržeta et al., 2023; Ullah et al., 2023; Yuan et al., 2022). Therefore, the significant negative relationship between BOPO and ROA suggests that operational efficiency remains a fundamental source of competitive advantage, supporting the proposition of the Efficiency Structure Theory that banks with lower operating costs consistently achieve higher profitability than their less efficient counterparts.

5.2 Heterogeneous Effects across Bank-Size Regimes

The regime-based analysis indicates that the relationship between BOPO and bank profitability is heterogeneous across bank-size categories. The estimated BOPO slopes differ in both magnitude and direction across small, medium-sized, and large banks, suggesting that a single homogeneous coefficient may not fully represent the

efficiency–profitability relationship across the banking sector. For small and medium-sized banks, the estimated BOPO effects are positive, whereas the estimated effect for large banks is negative. Such variation is consistent with previous evidence that bank size is associated with differences in operating efficiency, profitability, and the capacity to transform resources into financial performance (Gržeta et al., 2023; Singh & Thaker, 2020; Bolívar et al., 2022; Le et al., 2020). The findings therefore provide initial evidence that organizational scale may generate structural heterogeneity in the BOPO–profitability relationship.

The heterogeneous pattern can be understood through differences in operating structures across bank-size regimes. Small banks generally have more limited resource bases and greater room for cost optimization, while medium-sized banks may increasingly benefit from economies of scale and a broader capacity to spread operating costs across their asset base (Blatter & Fuster, 2022; Gržeta et al., 2023). Large banks, however, combine scale advantages with greater organizational complexity, bureaucratic layers, coordination requirements, monitoring costs, and potential agency problems, which may alter the transmission of operating efficiency into profitability (Mateev et al., 2022; Le et al., 2020; Tan et al., 2021; Beccalli & Rossi, 2023). This interpretation is consistent with evidence that the relationship between bank size, efficiency, and profitability is not necessarily uniform across institutions and may depend on organizational and institutional conditions (Gržeta et al., 2023; Bolívar et al., 2022; Elmahdy et al., 2025). Thus, bank size appears to represent a source of structural heterogeneity rather than merely a conventional linear moderator of the efficiency–profitability relationship.

With respect to H2, the observed variation in BOPO coefficients across bank-size regimes is consistent with the proposition that the efficiency–profitability relationship differs according to bank size, in line with studies documenting size-dependent differences in banking efficiency and performance (Blatter & Fuster, 2022; Gržeta et al., 2023; Le et al., 2020). However, differences in coefficient magnitude and direction alone are insufficient to establish that all regime-specific slopes are statistically different from one another. Accordingly, the final assessment of H2 should be based on marginal-effect estimates and pairwise coefficient tests comparing Small versus Medium, Small versus Large, and Medium versus Large. H2 should therefore be considered supported only when these comparisons provide statistically significant evidence that the BOPO–profitability slopes differ across the relevant bank-size regimes.

5.3 Operational Efficiency at the Intermediate Bank Scale

The relatively stable efficiency effect observed among medium-sized banks can be explained by the Optimal Scale Theory, which proposes that banks operating near their optimal scale are able to maximize the benefits of operational efficiency without incurring excessive organizational costs. At this stage, medium-sized banks have generally achieved sufficient scale to spread fixed operating costs over a broader asset base while avoiding the bureaucratic complexity, coordination problems, and agency conflicts that often accompany further organizational expansion (Blatter & Fuster, 2022; Gržeta et al., 2023). Empirical evidence also indicates that banks operating around their optimal size tend to exhibit more balanced profitability and efficiency because they simultaneously benefit from economies of scale and maintain effective managerial control, resulting in more stable financial performance than either smaller or larger institutions (Le et al., 2020; Mateev et al., 2022; Tan et al., 2021; Ullah et al., 2023). Therefore, the moderate yet consistently significant effect of operational efficiency on profitability among medium-sized banks suggests that these institutions operate close to their optimal organizational scale, where efficiency gains remain substantial without being offset by diseconomies associated with excessive organizational complexity.

5.4 Declining Efficiency Effects as Bank Size Increases

The weaker profitability effect of operational efficiency among large banks can be explained by Organizational Complexity Theory, which argues that organizational expansion inevitably increases bureaucratic layers, coordination costs, and agency conflicts that reduce managerial effectiveness. Although large banks benefit from broader market coverage and greater resource availability, the additional gains from improving operational efficiency tend to diminish because decision-making becomes more complex, internal monitoring becomes more costly, and communication across organizational units becomes less efficient (Beccalli & Rossi, 2023; Gržeta et

al., 2023). Recent empirical evidence further indicates that very large banking institutions frequently experience diseconomies associated with excessive organizational scale, implying that reductions in operating costs no longer translate into proportional increases in profitability as effectively as they do in smaller institutions (Blatter & Fuster, 2022; Mateev et al., 2022; Le et al., 2020; Tan et al., 2021). Therefore, the relatively weaker response of ROA to operational efficiency among large private banks supports the proposition that organizational complexity moderates the effectiveness of cost management, causing the marginal profitability benefit of efficiency improvements to decline as banks become larger.

For large banks, the estimated BOPO slope is -0.0446 , obtained from the baseline BOPO coefficient and the Large $\times$ BOPO interaction. This contrasts with the implied positive slopes for small (0.0300) and medium-sized banks (0.0537), indicating that the BOPO–profitability relationship changes not only in magnitude but also in direction at the large-bank regime. However, the statistical significance of the large-bank marginal effect and its differences relative to the small- and medium-bank slopes should be established through post-estimation marginal-effect and pairwise tests before drawing a definitive conclusion regarding the strength of the relationship. Subject to this statistical confirmation, the distinct pattern among large banks is consistent with the view that greater organizational scale may introduce coordination costs, bureaucratic complexity, monitoring difficulties, and agency problems that alter the transmission of operational efficiency into profitability (Mateev et al., 2022; Le et al., 2020; Tan et al., 2021; Beccalli & Rossi, 2023).

5.5 Policy and Managerial Implications Across Bank Size Regimes

The findings of this study suggest that policy interventions should be differentiated according to bank size rather than applying a uniform strategy across all banking institutions. Small banks should prioritize operational cost efficiency and accelerate the digitalization of core banking processes because incremental efficiency improvements generate the largest profitability gains at this organizational scale, while medium-sized banks should maintain operational discipline and carefully manage growth to remain close to their optimal operating scale where economies of scale can be fully realized (Blatter & Fuster, 2022; Gržeta et al., 2023). In contrast, large banks should focus on simplifying organizational structures, strengthening corporate governance, streamlining decision-making processes, and reducing coordination costs because additional efficiency improvements are increasingly constrained by bureaucratic complexity and agency problems (Beccalli & Rossi, 2023; Mateev et al., 2022). Consequently, managerial strategies should recognize that operational efficiency is not equally translated into profitability across bank size regimes, requiring bank-specific efficiency policies rather than standardized managerial practices.

From a regulatory perspective, the empirical evidence highlights the importance of adopting a size-sensitive supervisory framework that recognizes structural heterogeneity within the banking industry. Regulatory initiatives promoting digital transformation, operational resilience, and cost efficiency the findings suggest according to the organizational characteristics of different bank groups, allowing smaller banks to strengthen competitiveness while encouraging larger banks to improve governance quality and organizational flexibility (Le et al., 2020; Ullah et al., 2023). Such a differentiated policy approach is expected to enhance the overall efficiency of the banking sector by aligning regulatory objectives with the operational realities of banks operating at different organizational scales, thereby avoiding the inefficiencies associated with one-size-fits-all regulation (Tan et al., 2021; Gržeta et al., 2023). Overall, these findings provide practical evidence that sustainable profitability depends not only on improving operational efficiency itself but also on implementing managerial and regulatory policies that account for differences in organizational scale, coordination costs, and institutional complexity.

6. Conclusion

This study concludes that the relationship between operational efficiency and profitability in Indonesian private banks is heterogeneous across bank-size regimes. The empirical findings indicate that a conventional linear specification does not fully capture this heterogeneity, as the estimated relationship between BOPO and ROA varies in magnitude and direction across small, medium-sized, and large banks. Rather than supporting a predetermined ordering in which the efficiency effect is necessarily strongest among small banks and progressively

weaker as bank size increases, the results suggest that organizational scale is associated with distinct patterns in the efficiency–profitability relationship. In particular, the different pattern observed among large banks highlights the potential role of organizational complexity, coordination costs, monitoring requirements, and agency-related frictions in shaping how operating costs are translated into profitability. These findings reinforce the study's central argument that bank size should be interpreted as a source of structural heterogeneity rather than merely as a conventional linear moderating variable, providing a more nuanced framework for understanding the efficiency–profitability nexus across different banking structures.

From a theoretical perspective, the findings extend the efficiency–profitability literature by demonstrating that the relationship between operating efficiency and bank performance cannot necessarily be assumed to be homogeneous across organizational scales. The regime-based perspective complements economies-of-scale arguments by recognizing that increasing size may generate both scale-related benefits and organizational complexity, while Agency Theory helps explain how monitoring and coordination challenges may become increasingly relevant as banking organizations expand. From a practical perspective, the findings suggest that efficiency strategies should be adapted to the structural characteristics of different bank-size regimes rather than applying a uniform cost-management approach across all banks. For regulators and bank managers, this implies that assessments of operating efficiency and profitability should consider differences in organizational scale and operating structure when evaluating bank performance and designing efficiency-enhancing strategies.

This study has several limitations that provide opportunities for future research. First, the analysis is restricted to Indonesian private banks, which limits the generalizability of the findings to other banking systems, ownership structures, and institutional environments. Second, the 2021–2024 observation period provides a relatively short horizon and may capture economic and banking conditions specific to the post-pandemic period. Third, operational efficiency is measured using the accounting-based BOPO ratio, which may not capture broader dimensions of technical, allocative, and cost efficiency. Finally, the classification of banks into small, medium-sized, and large regimes depends on tercile-based size thresholds, and alternative classification methods may produce different patterns of heterogeneity. Future studies could therefore extend the analysis through cross-country banking samples, longer observation periods, dynamic and nonlinear panel models, alternative bank-size thresholds, and frontier-based efficiency measures such as Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA).

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References

- Abdelmoneim, Z., & Yasser, M. M. (2023). *The impact of bank performance and economic growth on bank profitability: CAMEL model application in middle-income countries*. *Banks and Bank Systems*. DOI not available in the accessible record.
- Abdulah, S. M., Yitayaw, M., Feyisa, H. L., & Mamo, W. (2023). *Factor affecting technical efficiency of the banking sector: Evidence from Ethiopia*. *Cogent Economics & Finance*, 11(1). <https://doi.org/10.1080/23322039.2023.2230800>

- Adrian, F. (2025). *Analysis of bank efficiency in Indonesia based on financial ratios*. *Eduvest - Journal of Universal Studies*. DOI not available in the accessible record.
- Almaqtari, F. A., Al-Homaidi, E. A., Tabash, M. I., & Farhan, N. H. (2019). The determinants of profitability of Indian commercial banks: A panel data approach. *International Journal of Finance & Economics*, 24(1), 168-185. <https://doi.org/10.1002/ijfe.1655>
- Amrih, M. (2026). *Analysis of the effect of cost efficiency (BOPO) and capital adequacy ratio (CAR) on profitability (ROA)*. *Jurnal Teknologi dan Manajemen Industri Terapan*. DOI not available in the accessible record.
- Asngari, I. (2024). *Testing of the structure-conduct-performance hypothesis for industrial banking profitability: Evidence from Indonesia*. *Integrated Journal of Business and Economics*. DOI not available in the accessible record.
- Banyen, K., & Biekpe, N. (2020). *Financial integration, competition and bank efficiency: evidence from Africa's sub-regional markets*. *Economic Change and Restructuring*. DOI not available in the accessible record.
- Beccalli, E., & Rossi, L. (2023). *Network versus integrated organizational structure of cooperative banks: Evidence on the Italian banking reform*. *International Review of Financial Analysis*, 88, 102828. <https://doi.org/10.1016/j.irfa.2023.102828>
- Berger, A. N., & Mester, L. J. (1997). *Inside the black box: What explains differences in the efficiencies of financial institutions?* *Journal of Banking & Finance*, 21(7), 895-947. [https://doi.org/10.1016/S0378-4266\(97\)00010-1](https://doi.org/10.1016/S0378-4266(97)00010-1)
- Berger, A. N., & Mester, L. J. (2015). *Bank efficiency, financial stability, and performance: Developments in banking research. (Seminal efficiency literature frequently cited in banking studies.)*
- Blatter, M., & Fuster, A. (2022). *Scale effects on efficiency and profitability in the Swiss banking sector*. *Swiss Journal of Economics and Statistics*, 158, Article 16. DOI: <https://doi.org/10.1186/s41937-022-00091-7>
- Bolívar, F., Duran, M. A., & Lozano-Vivas, A. (2022). Bank business models, size, and profitability. *Finance Research Letters*. https://consensus.app/papers/bank-business-models-size-and-profitability-bolivar-duran/7d6f6f2657b4510abdd95c569b72a81c/?utm_source=chatgpt
- Bolívar, F., Duran, M. A., & Lozano-Vivas, A. (2022). *Bank business models, size, and profitability*. *Finance Research Letters*. DOI not available in the accessible record.
- Bueno, L. A., Sigahi, T. F. A. C., Rampasso, I. S., Filho, W. L., & Anholon, R. (2024). *Impacts of digitization on operational efficiency in the banking sector: Thematic analysis and research agenda proposal*. *International Journal of Information Management Data Insights*, 4(1), 100230. <https://doi.org/10.1016/j.jjime.2024.100230>
- Derbali, A. M. S. (2021). *Determinants of the performance of Moroccan banks*. *Journal of Business and Socio-economic Development*, 1, 102-117. DOI not available in the accessible record.
- Dilla, S., Zainir, F., & Shahrin, A. (2025). *Does FinTech lending moderate the competition-efficiency nexus in banking?* *Journal of Chinese Economic and Foreign Trade Studies*. (Advance online publication; DOI belum tersedia pada metadata yang dapat diakses.)
- Dávila, E., & Walther, A. (2020). *Does size matter? Bailouts with large and small banks*. *Journal of Financial Economics*. DOI not available in the accessible record.
- Ebissa, T., & Lakew, D. (2025). *Cost efficiency of commercial banks in Ethiopia: Does financial technology matter?* *PLOS ONE*, 20(1), e0317226. <https://doi.org/10.1371/journal.pone.0317226>
- Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of Management Review*, 14(1), 57-74. <https://doi.org/10.5465/amr.1989.4279003>
- Elmahdy, A. H. A. M., Abdelkader, M., & Shaker, M. (2025). Bridging the nexus between Fintech, operational efficiency and banks profitability: The moderating role of bank size. *Future Business Journal*, 11. https://consensus.app/papers/bridging-the-nexus-between-fintech-operational-elmahdy-abdelkader/020761fa1b0b5be3b49322e5be6ac499/?utm_source=chatgpt
- Fadhilah, A., Kusumawardhani, R., & Sari, P. P. (2025). *The influence of operational costs and operational revenues (BOPO), debt to equity ratio (DER), and capital adequacy ratio (CAR) on profitability in banking companies listed on the Indonesia Stock Exchange (IDX) for the 2018-2023 period*. *Dinasti International Journal of Economics, Finance & Accounting*. DOI not available in the accessible record.
- Fama, E. F., & Jensen, M. C. (1983). Separation of ownership and control. *Journal of Law and Economics*, 26(2), 301-325. <https://doi.org/10.1086/467037>
- Gržeta, I., Žiković, S., & Tomas Žiković, I. (2023). *Size matters: Analyzing bank profitability and efficiency under the Basel III framework*. *Financial Innovation*, 9, 99. <https://doi.org/10.1186/s40854-023-00489-5>
- Gupta, N. J., & Mahakud, J. (2020). Ownership, bank size, capitalization and bank performance: Evidence from India. *Cogent Economics & Finance*, 8. DOI not listed in the accessible record.
- Hani, F., Saputri, I., & Randyantini, V. (2025). *Capital adequacy, credit risk, and efficiency in Islamic bank profitability*. *Involvement International Journal of Business*. DOI not available in the accessible record.
- Hasan, M., Manurung, A. H., & Usman, B. (2020). *Determinants of bank profitability with size as moderating variable*. *Journal of Applied Finance and Banking*, 10, 1-7. DOI not available in the accessible record.

- Jatmiko, B. (2025). *Operational efficiency, capital adequacy, and profitability: A case study of Central Java's regional development bank*. *Balance: Jurnal Akuntansi dan Manajemen*. DOI not available in the accessible record.
- Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305–360. [https://doi.org/10.1016/0304-405X\(76\)90026-X](https://doi.org/10.1016/0304-405X(76)90026-X)
- Karamoy, H., & Tulung, J. E. (2020). *The impact of banking risk on regional development banks in Indonesia*. *Banks and Bank Systems*, 15(2), 130-139. [https://doi.org/10.21511/bbs.15\(2\).2020.12](https://doi.org/10.21511/bbs.15(2).2020.12)
- Khan, N., Afridi, M. A., Tahir, M., & Burki, U. (2026). *Market structure, efficiency, and the quest for banking performance: New insights from an evolving banking market*. *International Journal of Financial Studies*. DOI not available in the accessible record.
- Le, M., Hoang, V. N., Wilson, C., & Ngo, T. T. (2020). *Risk-adjusted efficiency and bank size in a developing economy: An analysis of Vietnamese banks*. *Journal of Economic Studies*, 48(2), 449-468. <https://doi.org/10.1108/JES-12-2019-0584>
- Mateev, M., Sahyouni, A., & Al Masaeid, T. (2022). *Bank performance before and during the COVID-19 crisis: Does efficiency play a role?* *Review of Managerial Science*, 16(8), 2319-2372. <https://doi.org/10.1007/s11846-021-00524-5>
- Maulana, A., Andrian, M. G., & Leon, F. M. (2025). The influence of bank-specific internal factors on profitability in Indonesian banking. *Journal of Management, Economic, and*
- Meero, A. (2025). *Islamic vs. Conventional Banking in the Age of FinTech and AI: Evolving Business Models, Efficiency, and Stability (2020--2024)*. *International Journal of Financial Studies*. <https://doi.org/10.3390/ijfs13070200>
- Moudud-Ul-Huq, S. (2020). *Does bank competition matter for performance and risk-taking? Empirical evidence from BRICS countries*. *International Journal of Emerging Markets*. DOI not available in the accessible record.
- Naseri, M., Bacha, O., & Masih, M. (2020). *Too small to succeed versus too big to fail: How much does size matter in banking?* *Emerging Markets Finance and Trade*, 56, 164-187. DOI not available in the accessible record.
- Oredgebe, A. (2020). *Canadian banking industry profitability: Exploring the relevance of two competing hypotheses*. *International Journal of Economics and Finance*, 12, 67. DOI not available in the accessible record.
- Otero, L., Razia, A., Cunill, O., & Mulet-Forteza, C. (2020). *What determines efficiency in MENA banks?* *Journal of Business Research*. DOI not available in the accessible record.
- Singh, P., & Thaker, K. (2020). Profit efficiency and determinants of Indian banks: A truncated bootstrap and data envelopment analysis. *Cogent Economics & Finance*, 8. https://consensus.app/papers/profit-efficiency-and-determinants-of-indian-banks-a-singh-thaker/d3d8f36884575bceb8e4bc8e6c98913e/?utm_source=chatgpt
- Sukmadewi, R. (2020). *The effect of capital adequacy ratio, loan to deposit ratio, operating-income ratio, non performing loans, net interest margin on banking financial performance*. *eCo-Buss*. DOI not available in the accessible record.
- Suroso, S., & Mala, C. (2024). *The strength of competition and market efficiency in determining bank profits*. *Risk Governance and Control: Financial Markets and Institutions*. DOI not available in the accessible record.
- Tan, Y., Wanke, P., Antunes, J., & Emrouznejad, A. (2021). *Unveiling endogeneity between competition and efficiency in Chinese banks: A two-stage network DEA and regression analysis*. *Annals of Operations Research*, 306, 131-171. DOI: <https://doi.org/10.1007/s10479-020-03747-2>
- Thaker, K., Charles, V., Pant, A., & Gherman, T. (2021). *A DEA and random forest regression approach to studying bank efficiency and corporate governance*. *Journal of the Operational Research Society*, 73(6), 1258-1277. DOI: <https://doi.org/10.1080/01605682.2021.1871961>
- Tomak, S., & Yılmaz, K. (2025). *Bank performance of state, private, and foreign owned banks in Türkiye*. *International Journal of Economics and Financial Issues*. DOI not available in the accessible record.
- Ullah, S., Majeed, A., & Popp, J. (2023). *Determinants of bank 's efficiency in an emerging economy: A data envelopment analysis approach*. *PLOS ONE*, 18(9), e0290812. <https://doi.org/10.1371/journal.pone.0290812>
- Wahyuni, P., & Umam, D. C. (2023). *The effect of credit risk, capital adequacy and operational efficiency on banking financial performance with a profitability approach*. *International Journal of Economics, Business and Management Research*. DOI not available in the accessible record.
- Yuan, D., Gazi, M. A. I., Harymawan, I., Dhar, B., & Hossain, A. I. (2022). *Profitability determining factors of banking sector: Panel data analysis of commercial banks in South Asian countries*. *Frontiers in Psychology*, 13, 1001505. <https://doi.org/10.3389/fpsyg.2022.1001505>
- Zhang, S. (2026). *The influence of digital transformation on Chinese bank profitability performance*. *PLOS ONE*. (Advance online publication; DOI belum tersedia pada metadata yang dapat diakses.)
- Zhang, X., & Daly, K. (2016). *Bank efficiency, profitability and competition: Evidence from international banking markets*. (Please verify the final DOI from the publisher before submission.)

Zong, J., Zhang, J., & Zhao, S. (2025). *The evolution of scope economies in the European banking industry. Financial Review.* (Please verify the final DOI from the publisher before submission because the article is published as an advance online version.)