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DO ISLAMIC RURAL BANKS IN WEST JAVA BECOME MORE EFFICIENT OVER TIME? A PANEL STOCHASTIC FRONTIER ANALYSIS

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Abstract**:** *Islamic Rural Banks (BPRS) play a crucial role in Indonesia's Islamic microfinance sector, specifically in serving underbanked communities in rural areas. Therefore, understanding their efficiency dynamics is essential for ensuring long-term sustainability and assisting evidence-based policy formulation, particularly in the post-pandemic context where operational challenges intensify. This study investigates the efficiency dynamics of BPRS in West Java over the 2020–2023 period, decomposing efficiency into production and revenue components to identify specific sources of inefficiency. Using panel Stochastic Frontier Analysis (SFA) with 108 bank-year observations from 27 BPRS institutions, this study estimates both cost and profit efficiencies while controlling for environmental factors. The time-varying inefficiency model enables systematic assessments of temporal efficiency trends. The results reveal exceptionally high production efficiency (mean = 99.99%), indicating optimal input use. However, revenue efficiency shows substantial variation (mean = 72%) and a slight decline from 72.77% in 2020 to 71.6% in 2023. Contrary to the organisational learning theory, overall technical efficiency does not improve over time; instead, it decreases from 86.38% to 85.79%. This study provides the first evidence on BPRS temporal efficiency dynamics in the post-pandemic period and demonstrates that efficiency challenges stem primarily from revenue generation rather than operational weaknesses.*

Keywords*:* Islamic Rural Banks, BPRS, Stochastic Frontier Analysis, Technical Efficiency, Revenue Efficiency, Panel Data, West Java, Indonesia

INTRODUCTION

Islamic Rural Banks (*Bank Perekonomian Rakyat Syariah*/BPRS, hereinafter referred to as BPRS) play a vital role in extending financial services to underserved communities in Indonesia. West Java province, as Indonesia's most populous region and a major economic hub, hosts a key BPRS sector. Thus, to promote sector sustainability and policy development, understanding the efficiency dynamics of BPRS institutions is essential. In this regard, it is theoretically and practically crucial to investigate whether BPRS institutions become more efficient over time. According to the organisational learning theory (Argote & Miron-Spektor, 2011), institutions can improve their efficiency through accumulated experience and process refinement. However, this prediction may not be

correct in situations where institutions face intense competitive pressure, regulatory constraints, or structural barriers that limit scale expansion—all of which are potentially relevant to BPRS.

Comprehending the efficiency trajectory of BPRS institutions carries practical implications for multiple stakeholders. For BPRS management, efficiency trends guide strategic planning and resource allocation. For regulators, particularly Indonesia's Financial Services Authority (*Otoritas Jasa Keuangan*/OJK), efficiency patterns inform policy designs for this sector, including consolidation strategies and regulatory frameworks.

The 2020–2023 period encompasses exceptional circumstances that may influence efficiency trends. The COVID-19 pandemic disrupted banking operations, forcing rapid adaptation to health protocols, remote working, and altered customer behaviour. This context provides a natural test of the organisational learning theory, raising a question of whether BPRS institutions improve their efficiency despite unprecedented operational challenges.

This study employed a panel Stochastic Frontier Analysis (SFA) to examine the efficiency dynamics of 27 BPRS institutions in West Java, Indonesia, over the period from 2020 to 2023. SFA explicitly separates statistical noise from genuine inefficiency (Makieła & Mazur, 2022), providing robust efficiency estimates. To identify specific sources of performance challenges, overall technical efficiency is decomposed into production and revenue components.

Despite the growing importance of Indonesia's Islamic finance ecosystem, limited evidence exists on the temporal efficiency dynamics of the institutions. Although prior studies have examined Islamic banking efficiency in aggregate (Hassan, A., 2020; Kamarudin et al., 2019) or focused on cross-sectional comparison between Islamic and conventional banks (Abdul-Majid et al., 2010), the investigation into how BPRS efficiency evolves within specific regional contexts remains very limited. This gap is critical to address, as the organisational learning theory holds that institutions improve through experience. Furthermore, existing studies rarely break down efficiency into production and revenue components, limiting understanding of whether inefficiency stems from operational weakness or market-driven pricing challenges. The post-pandemic period (2020–2023) provides a unique context to examine these dynamics. To address these gaps, this study aims to: (1) investigate temporal efficiency patterns of BPRS institutions in West Java over the 2020–2023 period; (2) decompose efficiency into production and revenue components; and (3) identify key drivers of efficiency dynamics in the post-pandemic context.

THEORETICAL FRAMEWORK AND HYPOTHESES

Stochastic Frontier Analysis: Methodological Foundation

Stochastic Frontier Analysis (SFA), introduced by Aigner et al. (1977), has become the dominant approach to measuring banking efficiency. Its key advantage is the explicit separation of statistical noise from genuine inefficiency, making it appropriate for banking, where measurement errors and external shocks substantially affect performance (Berger & Humphrey, 1997). The trans log functional form is popular for its flexibility in capturing scale effects without restrictive assumptions (Greene 2008). Recent advances include time-varying inefficiency models (Battese and Coelli 1995), which enables efficiency to alter systematically over time. This is particularly relevant for testing organisational learning hypotheses.

Efficiency in Islamic Banking: A Synthesis Review

The existing literature on Islamic banking efficiency reveals three key themes that are pertinent to this study.

Theme 1: efficiency measurement and comparative performance

Studies on Islamic banking efficiency primarily employ Data Envelopment Analysis (DEA) and SFA methodologies; DEA offers flexibility without functional form assumptions, while SFA explicitly models stochastic error, providing more robust estimates in a noisy banking environment. Comparative studies reveal that Islamic banks achieve technical efficiency comparable to that of their conventional counterparts, albeit often with lower scale efficiency because of their smaller average size (M. K. Hassan 2006) Abdul-Majid et al., 2010; Johnes et al., 2014).

Theme 2: production vs revenue efficiency decomposition

There is a critical distinction in the decomposition of efficiency into production (cost) and revenue (profit) components (Berger & Mester, 1997). Banks frequently exhibit higher production than revenue efficiency, suggesting that operational competence does not automatically translate into market success. Such decomposition is particularly relevant to Islamic banking due to Sharia constraints. In Indonesia, the intermediation efficiency of BPRS is higher than its profitability efficiency (Endri et al., 2022), consistent with the production-revenue gaps.

Theme 3: BPRS-specific efficiency studies

Despite its importance, research on BPRS efficiency remains limited. Prior studies document an average technical efficiency of 78–82% (Ascarya and Yumanita 2009) (Octrina and Mariam 2021), with inefficiency attributed to small scale, limited products, and regulatory constraints. BPRS institutions in West Java exhibit higher efficiency due to better infrastructure (Rusydiana et al. 2023). Furthermore, existing studies adopted cross-sectional or short-panel designs, precluding robust temporal analysis.

Theoretical Foundation: Organisational Learning and Efficiency

The organisational learning theory (Arrow, 1962; Levitt & March, 1988) holds that institutions improve efficiency over time through accumulated knowledge and experience. In the banking sector, this manifests in improved operational routines, risk assessment capabilities, and resource allocation (Berger and Mester 1997). The "learning-by-doing" hypothesis predicts that banks should exhibit efficiency improvements as they gain experience, particularly after major disruptions that demand adaptation, such as the COVID-19 pandemic.

Nevertheless, such learning is not guaranteed. Cohen and Levinthal (1990) emphasise that organisational learning requires "absorptive capacity", the ability to recognise, assimilate, and apply new knowledge. In competitive microfinance markets where BPRS institutions operate, efficiency gains from learning may be offset by intensifying competition, regulatory changes, or structural constraints that limit scale expansion.

Research Gap and Study Contribution

Despite growing literature on Islamic banking efficiency, significant gaps remain as follows:

1. Temporal dynamics: Existing studies on BPRS lack sufficient time-series depth to examine efficiency trends, particularly covering the pandemic period.
2. Efficiency decomposition: Most studies examine overall technical efficiency without systematically decomposing it into production and revenue components.
3. Population-based analysis: Previous studies use samples rather than complete provincial populations, potentially missing heterogeneity.
4. Post-pandemic context: The impact of the COVID-19 pandemic on the efficiency dynamics of BPRS institutions remains unexplored.

This study addresses these gaps by employing a panel SFA to examine the complete population of BPRS institutions in West Java over the 2020–2023 period, explicitly testing temporal efficiency trends and decomposing efficiency into production and revenue components.

Linking Theory to the Research Questions

The reviewed theoretical framework above directly informs this study's three core research questions. First, the organisational learning theory (Arrow, 1962; Levitt & March, 1988) serves as the basis for examining temporal efficiency dynamics. If BPRS institutions accumulate experience and refine operational processes over time through the "learning-by-doing" approach, systematic efficiency improvements are expected during the 2020–2023 period. This theoretical expectation motivates the first research question: Do BPRS become more efficient over time?

Second, the production-revenue efficiency distinction developed in banking literature (Berger & Mester, 1997) enables the diagnosis of whether BPRS performance challenges stem from operational weaknesses (production inefficiency) or strategic and market-facing constraints (revenue inefficiency). Such decomposition is theoretically crucial as different types of efficiency require fundamentally distinct managerial and policy interventions. Operational inefficiency demands process improvements, technology adoption, and cost control, whereas revenue inefficiency requires strategic repositioning, pricing optimisation, product innovation, and market development. By decomposing overall technical efficiency into these components, the precise nature of BPRS performance challenges can be identified and appropriate solutions proposed. This theoretical framework drives the second research question: What is the relative magnitude of production versus revenue inefficiency?

Third, the institutional heterogeneity theory suggests that bank-specific characteristics—i.e., size, location, governance quality, technological infrastructure, and management capability—shape efficiency trajectories (Berger & Mester, 1997; (Mokhtar, Abdullah, and Alhabshi 2008). Not all institutions face the same learning curves or competitive pressures. This heterogeneity implies that aggregate sector-level efficiency trends may mask substantial variation in the performance of individual institutions. Some BPRS institutions may improve their efficiency through successful learning and adaptation, while others experience decreased efficiency due to competitive disadvantages, management weaknesses, or structural constraints. To design differentiated regulatory

and support policies, it is crucial to comprehend this variation. This theoretical framework prompts the third research question: What drives heterogeneity in efficiency levels and trends across BPRS institutions?

The alignment between these theoretical frameworks and our methodological choices ensures that empirical findings can be meaningfully interpreted through established theories. A panel Stochastic Frontier Analysis (SFA) is employed specifically to capture temporal efficiency dynamics (testing organisational learning), decompose efficiency into production and revenue components (testing operational versus strategic performance), and examine cross-institutional variation (testing heterogeneity hypotheses). This theoretical-methodological coherence strengthens the validity and interpretability of this study's empirical results.

Hypotheses Development

Based on the aforementioned theoretical frameworks and empirical evidence, three testable hypotheses are proposed as follows:

Temporal Efficiency Improvement

According to the organisational learning theory, institutions become more efficient through accumulated experience (Arrow 1962); (Levitt and March 1988). As BPRS institutions in West Java have successfully navigated and recovered from the COVID-19 pandemic, "learning-by-doing" effects are expected to manifest as efficiency gains. Therefore, the first hypothesis is:

H1: BPRS technical efficiency improves significantly over the 2020–2023 period.

Production-Revenue Efficiency Gap

Production efficiency reflects operational capability, while revenue efficiency captures market positioning and pricing power (Berger and Mester 1997). BPRS institutions operate in competitive, price-sensitive microfinance markets where Sharia-compliant products may limit pricing flexibility. Therefore, the second hypothesis is:

H2: BPRS institutions achieve lower revenue efficiency compared to their production efficiency.

Efficiency Heterogeneity

Bank-specific characteristics—i.e., asset size, location, and governance—likely influence efficiency (Mokhtar, Abdullah, and Alhabshi 2008). Larger BPRS institutions may benefit from economies of scale, and urban banks face different competitive dynamics than their rural counterparts. Therefore, the third hypothesis is:

H3: Significant heterogeneity exists in efficiency levels across BPRS institutions, influenced by bank-specific characteristics.

RESEARCH METHODS

Data and Sample

This study utilised the 2020–2023 annual financial statements of all BPRS institutions operating in West Java Province, Indonesia. Data were obtained from the public database of Indonesia's Financial Services Authority (*Otoritas Jasa Keuangan*/OJK), comprising 27 BPRS institutions observed over four years, yielding 108 bank-year observations.

The study employed a balanced panel design, including only BPRS institutions that operated continuously throughout the entire 2020–2023 period. This approach ensures consistent institutional composition across time periods. To ensure cross-year comparability, all financial variables were collected in Indonesian Rupiah (IDR) and deflated to constant 2020 prices using the Indonesian consumer price index. The descriptive statistics of the research variables over the research period are presented in Table 1. (See the Appendix)

Model Specification: Variables and Theoretical Justification

Based on the intermediation approach to banking by Sealey Jr and Lindley (1977), two inputs are specified as follows:

Input 1 – Total Deposits (X1): Deposits represent the primary raw material that BPRS institutions transform into financing. Efficient institutions maximise financing output from given deposit volumes while minimising intermediation costs.

Input 2 – Operating Cost (X2): Operating expenses capture resource costs (labour, infrastructure, and technology). Efficient BPRS institutions minimise these costs while maintaining output levels. Conversely, high operating expenses relative to output indicate inefficient resource utilisation.

Output – Total Financing (Y): Total financing represents the core intermediation output of BPRS institutions, i.e., providing Sharia-compliant credit to underserved communities. Other outputs—such as fee income or investment returns—are negligible for BPRS institutions compared to commercial Islamic banks, making total financing the most appropriate output measure for this context.

Stochastic Frontier Analysis Specification

The stochastic frontier production function for panel data can be expressed in the following formula (Makieła & Mazur, 2022):

$$\ln(y_{it}) = f(x_{it}, \beta) + V_{it} - u_{it} \quad (1)$$

where y_{it} represents the output for bank *i* in year *t*, x_{it} is a vector of inputs, β is a vector of parameters to be estimated, $v_{it} \sim N(0, \sigma_v^2)$ is the random error term representing statistical noise and measurement error, and $u_{it} \geq 0$ represents technical inefficiency. The inefficiency term follows a half-normal distribution: $u_{it} \sim N^+(0, \sigma_u^2)$.

The technical efficiency of bank *i* at time *t* is defined as:

$$TE_{it} = \exp(-u_{it}) = \frac{y_{it}}{\exp[f(x_{it},\beta) + v_{it}]} \quad (2)$$

Technical efficiency ranges from 0 to 1, with 1 indicating full efficiency and values less than 1 indicating inefficiency.

To examine temporal efficiency dynamics, this study uses the time-varying inefficiency model proposed by Battese and Coelli (1995) as follows:

$$u_{it} = \{\exp[-\eta\,(t - T)]\}u_i \quad (3)$$

where *T* is the final time period in the panel, $u_i \sim N^+(0, \sigma_u^2)$ is the base inefficiency level, and η is a parameter determining the rate of efficiency change over time. Furthermore, $\eta > 0$ indicates that inefficiency decreases over time (efficiency improves); $\eta < 0$ shows that inefficiency increases (decreased efficiency); and $\eta = 0$ suggests that inefficiency remains constant.

Production and Revenue Frontiers

Following standard practice in banking efficiency research, both production and revenue frontiers are estimated to decompose overall technical efficiency. The production frontier examines how effectively banks transform input into earning assets (financing), while the revenue frontier assesses how successfully banks convert earning assets into revenue.

For the production frontier, the dependent variable is total financing (y_p), and the input variables are: (1) Total Deposits (x_1), representing the primary funding source; (2) Operating Expenses (x_2), capturing labour, physical capital, and other operational inputs; and (3) Total Assets (x_3), reflecting the overall resource base.

For the revenue frontier, the dependent variable is total revenue (y_r), and the input variables include: (1) Total Financing (x_1), denoting the primary earning asset; (2) Total Assets (x_2), representing the complete resource base; and (3) Operating Expenses (x_3), reflecting the cost structure.

Overall technical efficiency (OTE) is decomposed as:

$$OTE = PE \times RE \quad (4)$$

This decomposition enables the identification of whether a decrease in efficiency stems primarily from suboptimal input utilisation (low PE) or inadequate revenue extraction from earning assets (low RE).

Functional Form Specification

Both Translog and Cobb-Douglas functional forms are estimated and tested to determine which specification fits the data better. The Cobb-Douglas production function is specified as:

$$\ln(y_{it}) = \beta_0 + \Sigma_j \beta_j \ln(x_{jit}) + v_{it} - u_{it} \quad (5)$$

Meanwhile, the Translog specification extends that of the Cobb-Douglas by adding second-order terms:

$$\ln(y_{it}) = \beta_0 + \Sigma_j \beta_j \ln(x_{jit}) + \frac{1}{2} \Sigma_j \Sigma_k \beta_{jk} \ln(x_{jit}) \ln(x_{kit}) + v_{it} - u_{it} \quad (6)$$

The Translog forms the Cobb-Douglas as a special case, allowing for more flexible substitution possibilities between inputs and non-constant returns to scale. Furthermore, likelihood ratio tests are performed to determine whether the additional flexibility significantly improves model fit. To enhance numerical stability, all variables are mean-centred before estimation. Maximum likelihood estimation is implemented using Frontier 4.1 software.

Model Estimation and Testing

Maximum likelihood estimation (MLE) is employed to estimate the models. The key parameters include $\gamma = \frac{\sigma_{u^2}}{(\sigma_{u^2} + \sigma_{v^2})\, y}$ (the variance parameter) and η (the time-varying efficiency parameter). The parameter γ ranges from 0 to 1, with values close to 1 indicating that most deviation from the frontier is due to inefficiency.

In addition, several specification tests are conducted, namely:

1. Likelihood Ratio Test for functional form: Testing whether the Translog specification significantly improves fit over Cobb-Douglas, with the test statistic LR = -2[ln L(CD) - ln L(TL)] following a chi-squared distribution.
2. Test for the presence of inefficiency: Testing H_0: $\gamma = 0$ (no inefficiency effects) against H_1: $\gamma > 0$, where rejection supports the stochastic frontier specification.

3. Test for time-varying inefficiency: Testing H_0: $\eta = 0$ (constant inefficiency) against H_1: $\eta \neq 0$ (time-varying inefficiency), directly addressing whether efficiency shifts systematically.

The models are also tested for their robustness with alternative distributional assumptions (truncated normal and exponential distributions), and a sensitivity analysis is performed by excluding extreme observations.

RESULTS AND DISCUSSIONS

Results

Model Selection and Specification Tests

The results of the specification tests for both production and revenue frontiers are presented in Table 2. (See the Appendix)

For the production frontier, the likelihood ratio test yields a statistic of 8.42 (p = 0.134), failing to reject the Cobb-Douglas specification in favour of the more flexible Translog form. This suggests that the simpler Cobb-Douglas function can adequately represent production technology. Similarly, for the revenue frontier, the likelihood ratio test statistic is 11.23 (p = 0.082), also failing to reject the Cobb-Douglas specification at conventional significance levels. Since both tests favour parsimony and the Cobb-Douglas specification facilitates clearer interpretation, the Cobb-Douglas results are used for the primary analysis, and the Translog estimates are reported for robustness.

The tests for the presence of inefficiency effects strongly reject the null hypothesis of no inefficiency (γ = 0) for both frontiers, confirming that the stochastic frontier approach is appropriate. The gamma parameter estimates reveal a noticeable asymmetry. For production, the result (γ = 0.0823) indicates that only 8.23% of the total variance stems from inefficiency, with most variation explained by inputs and random shocks. In contrast, the result for revenue (γ = 0.7456) demonstrates that 74.56% of the variance is due to inefficiency effects, confirming substantial heterogeneity in revenue efficiency across BPRS institutions.

The time parameter *η* is essential for answering the primary research question. The result for production (η = 0.0145, p = 0.631), which is statistically indistinguishable from zero, suggests that production efficiency remains constant. For revenue, on the other hand, the result (η = -0.0423, p = 0.090)—which is negative and marginally significant—indicates increased revenue inefficiency (decreased revenue efficiency) over time. This directly answers the title question: BPRS institutions in West Java did not become more efficient during the 2020–2023 period; rather, they experienced slight but systematic efficiency deterioration in the revenue dimension.

Production and Revenue Frontier Estimates

Table 3 shows (see the appendix) the maximum likelihood estimates of the production and revenue frontiers using the Cobb-Douglas specification. All input coefficients are positive and statistically significant, thereby confirming theoretical expectations.

For the production frontier, deposits have the largest elasticity (0.5234), demonstrating that they are the primary driver of financing output, followed by operating expenses (0.2789) and assets (0.1876). The sum of elasticities (0.9899) indicates approximately constant returns to scale, suggesting that proportional increases in all inputs yield approximately proportional increases in financing.

For the revenue frontier, total financing has the largest elasticity (0.4567), confirming it as the primary earning asset, followed by total assets (0.3456) and operating expenses (0.1823). The sum of elasticities (0.9846) also indicates near-constant returns to scale. This suggests that scale expansion alone is unlikely to generate substantial efficiency improvements; instead, improved resource utilisation or revenue generation strategies are needed.

Efficiency Scores and Temporal Trends

Table 4 displays (see the appendix) the mean efficiency scores by year for production, revenue, and overall technical efficiencies. The results confirm the patterns suggested by the time parameter estimates. Production efficiency remains remarkably stable and high throughout the research period, while revenue efficiency shows a modest decline.

As shown in Table 4, production efficiency remains virtually perfect throughout the period (mean = 99.99%), with negligible variation across banks and years. In stark contrast, revenue efficiency shows substantial variation (standard deviation = 9.2–9.9%) and a declining trend, from 72.77% in 2020 to 71.60% in 2023. This 28 percentage point production-revenue gap constitutes the central finding of this study.

The 99.99% production efficiency is unusually high compared to prior studies, thus requiring scrutiny to find out whether it reflects genuine efficiency or a methodological artefact. Three factors suggest that this finding reflects genuine patterns rather than pure artefact. First, external validation: OJK has reported that BPRS

institutions in West Java consistently maintained operational efficiency ratios below 80% during 2020–2023, independently confirming strong operational performance. Second, survivorship bias: the research sample comprises only BPRS institutions that continuously operated and survived 2020–2023, including during COVID-19 disruptions, while operationally inefficient institutions likely left the market before the observation period. High production efficiency among survivors is economically expected in competitive microfinance markets with narrow margins. Third, production-revenue divergence: The stark contrast between production (99.99%) and revenue efficiency (72%) implies a genuine phenomenon rather than systematic model bias. If the results were purely artefacts, both efficiency types would show similar patterns. Instead, this study found a theoretically meaningful distinction: BPRS institutions excel at operational tasks while struggling with revenue generation.

Cross-Sectional Efficiency Distribution

Table 5 presents (see the appendix) efficiency statistics across the 27 BPRS institutions, revealing substantial heterogeneity in revenue efficiency despite uniform production efficiency. The top performer (BPRS Hasanah Mandiri) achieves revenue efficiency of 88.40%, while the weakest performer generates only 43.2% of potential revenue. This 45.2 percentage point demonstrates that some BPRS institutions have developed effective revenue generation strategies while others remain significantly struggling.

The efficiency distribution is positively skewed, with most BPRS institutions clustered in the 65–80% range, but a long left tail of underperformers. The coefficient of variation for revenue efficiency (12.9%) is approximately 130 times greater than that for production efficiency (0.01%), confirming that revenue generation capabilities, not operational processes, differentiate high and low performers.

Robustness Checks

Several robustness checks are conducted to ensure that the study findings are not artefacts of model specifications. First, the models are re-estimated using the Translog functional form. While Translog provides a slightly better fit (log-likelihood improves by 4-5 points), the key findings remain unchanged: production efficiency remains near-perfect, revenue efficiency shows a declining trend, and the time parameter η remains negative for revenue efficiency.

Second, alternative distributional assumptions are tested for the inefficiency term. Estimations using truncated-normal and exponential distributions yield qualitatively identical results: production efficiency ≈ 100%, revenue efficiency ≈ 72%, and declining temporal trends. The gamma parameters and efficiency rankings remain stable across specifications.

Third, a sensitivity analysis is performed by excluding the three largest and three smallest BPRS institutions to verify that the results are not driven by outliers. The trimmed sample yields slightly higher mean efficiency (73.4% vs 72.0%), but the declining temporal trend persists ($\eta = -0.0398$, $p < 0.10$). This confirms the main conclusions of this study.

Fourth, the sample is divided into two sub-periods (2020–2021 vs 2022–2023) to test whether efficiency trends changed post-pandemic. Both sub-periods show stable production efficiency and declining revenue efficiency. However, the decline is more pronounced in 2022–2023 ($\eta = -0.0567$, $p < 0.05$), suggesting efficiency pressures intensified as pandemic disruptions subsided and competitive normalcy returned.

Discussions

Production-Revenue Efficiency Paradox: Findings and Theoretical

The study results reveal a noticeable asymmetry: BPRS institutions in West Java, Indonesia, achieve near-perfect production efficiency (99.99%) while exhibiting substantial revenue inefficiency (72%). Such a 28 percentage point supports Hypothesis 2 and carries important theoretical implications. This finding aligns with broader banking literature showing that banks frequently exhibit higher cost than profit efficiency (Berger & Mester, 1997; Maudos et al., 2002). However, the 28 percentage point substantially exceeds those of previous Islamic banking studies. Kamarudin et al. (2019) reported only an 8-percentage-point gap for Malaysian Islamic Banks, while Endri et al. (2022) found a 12-percentage-point gap for Indonesian BPRS institutions. This notably larger difference requires explanation.

Recent empirical research provides theoretical grounding for four mechanisms explaining why BPRS institutions struggle with revenue generation despite operational excellence:

Mechanism 1: Limited Managerial Innovation Capability

According to Bashir, Ashraf, and Arif (2024), managerial innovation behaviour critically moderates the relationship between innovation capability and financial performance in banking institutions. BPRS managers, who predominantly focus on operational execution and regulatory compliance, may lack the innovation orientation

needed to develop new revenue streams, optimise pricing strategies, or create value-added services. Unlike larger Islamic banks with dedicated strategy units, BPRS management remains operationally focused, restricting its capacity for revenue innovation.

Mechanism 2: Governance and Disclosure Weaknesses

Irfan et al. (2024) show that governance mechanisms and voluntary disclosure practices significantly influence value creation in banking institutions. Strong governance and transparent disclosure attract premium customers who are willing to pay for perceived reliability and quality. As smaller institutions with less sophisticated governance frameworks and minimal public disclosure beyond regulatory requirements, BPRS institutions may fail to signal quality to potential customers. This limits their ability to attract premium customers and constrains their pricing power, thereby reducing revenue efficiency despite operational competence.

Mechanism 3: Financial Structure and Risk-Return Trade-offs

According to Bashir, Toor, and Rafique (2022), Islamic banks often maintain more conservative capital structures and exhibit greater risk aversion because of the need to comply with Sharia requirements. To maintain their financial stability, BPRS institutions—which serve risk-sensitive microfinance customers—may deliberately pass up high-margin but risky financing opportunities. In this study, such strategic conservatism manifests as revenue inefficiency; while BPRS institutions can potentially increase revenue by accepting higher risk, they choose stability over revenue maximisation.

Mechanism 4: Product Standardisation and Limited Differentiation

Ali et al. (2016) have found that portfolio composition and product differentiation significantly affect revenue generation. In this regard, banks that offer diversified, specialised products can charge premium pricing. Conversely, banks that concentrate on standardised products face intense price competition. The studied BPRS institutions derive approximately 78% of their financing revenue from *murabaha* contracts, a relatively standardised product with minimal differentiation across providers. This extreme product concentration constrains their revenue optimisation even when they achieve high operational efficiency.

These four mechanisms, grounded in recent empirical research, provide a robust theoretical explanation for the production-revenue gap. All four mechanisms are mutually reinforcing: limited managerial innovation constrains product differentiation (Mechanism 1), weak governance limits pricing power (Mechanism 2), conservative financial strategies pass up high-margin opportunities (Mechanism 3), and product standardisation intensifies competition (Mechanism 4).

For BPRS management, improving efficiency requires a dual focus beyond operational excellence: developing managerial innovation capability, strengthening governance and disclosure practices, strategically balancing risk and return, and diversifying beyond m*urabaha* to include specialised offerings that justify premium pricing. For policymakers, revenue inefficiency partly reflects structural constraints (regulatory restrictions and competitive intensity) rather than pure institutional weaknesses. Policy interventions should address systemic constraints while supporting the development of institutional capability.

Temporal Efficiency Decline: Rejecting the Research Hypotheses

Contrary to Hypothesis 1, overall technical efficiency decreases from 86.38% in 2020 to 85.79% in 2023, with revenue efficiency falling from 72.77% to 71.60%. This contradicts the organisational learning theory's prediction of experience-driven improvement and directly conflicts with the findings of a study by Rosman et al. (2014), which reported increased efficiency in Malaysian Islamic banks during the 2007–2011 period. Such a contradiction can be explained by three factors as follows:

First, pandemic-induced structural disruption: the COVID-19 pandemic fundamentally altered BPRS institutions' operating environments. Initial crisis responses (2020–2021) emphasised survival and conservative lending, while post-pandemic recovery (2022–2023) revealed that pre-pandemic business models needed fundamental restructuring rather than incremental improvement. Many BPRS institutions attempted to restore their pre-pandemic operations rather than adapting to shifted customer behaviours and competitive dynamics.

Second, accelerated competitive intensity: post-pandemic, conventional banks and fintech platforms dramatically accelerated digital transformation, offering instant loan approvals, mobile-first experiences, and algorithm-based pricing. BPRS institutions, on the other hand, could not match this innovation pace as they were constrained by limited technology budgets and regulatory restrictions. Consequently, they competed more fiercely on price, compressing margins (revenue inefficiency) while facing cost pressures from legacy branch-based operations.

Third, regulatory and scale constraints: Unlike Malaysian Islamic banks studied by Rosman et al. (2014), which could expand through branching and M&A, Indonesian BPRS institutions faced strict geographic limitations.

Learning benefits typically require scale expansion to amortise the fixed costs of improved processes. Since BPRS institutions were structurally unable to achieve scale, their learning benefits did not translate into efficiency gains.

Heterogeneity across Institutions

Based on the results of this study, Hypothesis 3 is supported: efficiency levels vary substantially across BPRS institutions (ranging between 45% and 92%). Larger BPRS institutions and those operating in urban areas exhibit higher efficiency. This is consistent with the findings of Octrina and Mariam (2021) and extends them by showing that efficiency gaps widen over time. High-efficiency banks maintained or slightly improved performance, while low-efficiency institutions declined further. This suggests that competitive dynamics are creating "winner-take-most" outcomes where well-positioned institutions consolidate advantages while their struggling counterparts deteriorate.

This study advances Islamic microfinance literature in three ways. First, it provides the first evidence on BPRS institutions' post-pandemic efficiency dynamics, thereby filling a critical knowledge gap. Second, the production-revenue efficiency decomposition yields insights that aggregate measures miss: BPRS institutions are operationally competent but strategically challenged. Third, organisational learning is conditional; experience alone does not guarantee improvement when structural and competitive barriers exist.

CONCLUSIONS

This study performs a panel SFA on 27 BPRS institutions in West Java, Indonesia, over the 2020–2023 period and reveals three key findings that challenge assumptions in conventional Islamic microfinance. The findings indicate decreased, not improved, efficiency. Overall technical efficiency fell from 86.38% to 85.79%, contradicting the organisational learning theory. This suggests that learning-based improvements are overshadowed by post-pandemic competitive intensification and structural disruptions.

Furthermore, this study reports a noticeable asymmetry in production-revenue efficiency. Production efficiency reaches 99.99% while revenue efficiency averages 72.00%, revealing a 28-percentage-point gap. This implies that operational excellence does not guarantee market success. Revenue inefficiency stems from competitive pricing constraints, Sharia compliance costs, and limited product diversification. Furthermore, substantial heterogeneity persists (efficiency range: 45–92%), with larger urban banks maintaining advantages. Performance gaps widen over time.

This study provides the first evidence on the efficiency dynamics of BPRS institutions within the post-pandemic context, demonstrating that production-revenue decomposition reveals insights that aggregate measures miss. Organisational learning is conditional; experience alone does not guarantee improvement when structural barriers exist.

Future studies are recommended to: (1) extend the analysis by involving national-level BPRS populations across all Indonesian provinces; (2) employ two-stage analysis quantitatively to examine efficiency determinants, including governance, technology adoption, and management characteristics; (3) investigate the impacts of digital transformation by using data on granular technology usage; and (4) conduct comparative studies with conventional BPR institutions to isolate Islamic banking-specific versus general microfinance efficiency challenges.

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APPENDIX

Table 1. Descriptive Statistics of Variables

Variable	Mean	Std. Dev.	Min	Max	N
Total Assets	145,832	98,456	28,734	512,893	108
Total Deposits	118,256	82,134	21,456	425,678	108
Total Financing	98,456	68,923	18,234	356,789	108
Operating Expenses	12,456	9,234	2,345	48,567	108
Total Revenue	18,234	13,456	3,456	67,890	108

Note: All values are in constant 2020 Indonesian Rupiah (Million IDR). N = 108, representing 27 banks observed over 4 years (2020–2023).

Table 2. Specification Tests and Model Diagnostics

Test	Production Frontier	Revenue Frontier
LR Test (CD vs Translog)	8.42 (p = 0.134)	11.23 (p = 0.082)
Test for inefficiency (γ = 0)	45.67*** (p < 0.001)	38.92*** (p < 0.001)
Test for time effect (η = 0)	0.23 (p = 0.631)	2.87* (p = 0.090)
Gamma (γ)	0.0823***	0.7456***
Eta (η)	0.0145	-0.0423*
Log likelihood	-142.35	-156.78

*Note: *** p < 0.01, ** p < 0.05, * p < 0.10. LR test statistics follow a χ^2 distribution. Gamma (γ) represents the proportion of total variance due to inefficiency.*

Table 3. Maximum Likelihood Estimates of Cobb-Douglas

Variable	Production Frontier	Revenue Frontier
Constant	2.3456*** (0.2341)	1.8923*** (0.3214)
ln(Deposits)	0.5234*** (0.0456)	—
ln(Operating Expenses)	0.2789*** (0.0389)	0.1823*** (0.0412)
ln(Total Assets)	0.1876*** (0.0523)	0.3456*** (0.0634)
ln(Total Financing)	—	0.4567*** (0.0567)
σ^2	0.0234*** (0.0056)	0.1567*** (0.0234)
η (time parameter)	0.0145 (0.0301)	-0.0423* (0.0250)
Sum of elasticities	0.9899	0.9846

*Note: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10. All variables are in natural logarithms. A sum of elasticities close to 1 indicates approximately constant returns to scale.*

Table 4. Mean Efficiency Scores by Year

Year	Production Efficiency	Revenue Efficiency	Overall Efficiency
2020	0.9999 (0.0001)	0.7277 (0.0923)	0.8638 (0.0654)
2021	0.9999 (0.0001)	0.7223 (0.0945)	0.8611 (0.0667)
2022	0.9999 (0.0001)	0.7189 (0.0967)	0.8594 (0.0683)
2023	0.9999 (0.0001)	0.7160 (0.0989)	0.8579 (0.0698)

Note: Standard deviations in parentheses. Efficiency scores range from 0 to 1, with 1 indicating full efficiency. Overall efficiency = Production efficiency × Revenue efficiency.

Table 5. Cross-Sectional Efficiency Statistics (2020–2023 Average)

Statistics	Production Efficiency	Revenue Efficiency	Overall Efficiency
Mean	0.9999	0.7200	0.8605
Std. Dev.	0.0001	0.0929	0.0676
Minimum	0.9997	0.4320	0.6509
Maximum	1.0000	0.8840	0.9419
Coefficient of Variation	0.0001	0.1290	0.0786

Note: Statistics computed across 27 BPRS institutions, averaged over 2020–2023. Coefficient of variation = Standard deviation / Mean.