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Comparative Efficiency Analysis of Conventional and Islamic Commercial Banks in Indonesia, 2020–2024: Evidence from Data Envelopment Analysis (DEA)

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Abstract

Indonesia operates a dual banking system in which Conventional Commercial Banks (BUK) and Islamic Commercial Banks (BUS) coexist under OJK supervision, yet an updated post-pandemic empirical reassessment covering the full 2020–2024 window that jointly applies CRS and VRS specifications and complements DEA with a formal non-parametric group comparison remains limited. This study estimates an output-oriented intermediation DEA model under both specifications using four inputs (total assets, operating expenses, third-party funds/DPK, and capital) and four outputs (loans or financing, interest income or profit-sharing, net income, and operating income) for a purposive sample of 11 BUK and 5 BUS (n = 80 bank-year observations). Because the Shapiro–Wilk test rejected normality for both groups under both specifications ($p < 0.001$), the Mann–Whitney U test was employed. Under CRS, Asymp. Sig. = 0.194 (> 0.05) indicates no significant overall technical-efficiency gap; under VRS, Asymp. Sig. = 0.018 (< 0.05) indicates a statistically significant difference with BUS attaining a higher mean rank (48.46 vs. 36.88), best interpreted as a scale-adjusted pure technical efficiency advantage. Both bank categories recorded mean efficiency scores below 1.00 under both specifications, signalling persistent inefficiency; the significant VRS result combined with the non-significant CRS result indicates that BUS inefficiency is largely scale-driven rather than managerial. Findings should be interpreted with caution given the inherently small BUS sample (n = 5 banks), which constrains statistical power and limits generalizability beyond the study's inclusion criteria.

KEYWORDS

constant return to scale (crs); data envelopment analysis (dea); efficiency; indonesian banking; scale efficiency; variable return to scale (vrs).

Introduction

In fostering a nation's economic stability, the banking sector occupies a pivotal position as a cornerstone of national economic development. Beyond its role in stimulating economic growth, the sector serves as a stabilising force, particularly through its core function as a financial intermediary. This intermediary role entails the mobilisation of surplus funds from entities with excess liquidity (surplus units) and their efficient allocation to entities experiencing capital shortages (deficit units), thereby facilitating the optimal circulation of financial resources within the economy (Ifanda Akbar & Wuryani, 2018).

Indonesia implements a dual banking system, integrating both conventional and Islamic banking frameworks within its financial architecture. Historically, the conventional banking sector was established earlier, with Islamic banking operations commencing only in 1992. This temporal advantage enabled conventional banks to dominate the national banking landscape for decades, both in terms of branch network

coverage and total asset holdings. However, the Islamic finance industry—particularly Islamic banking—has demonstrated substantial and accelerating growth in recent years, reflecting increasing public demand for Sharia-compliant financial services (Aisyah & Bakhtiar, 2024). Table 1 presents the development of the number of Conventional Commercial Banks and Islamic Commercial Banks in Indonesia from 2021 to 2024.

Based on Table 1, a contrasting trend is observed. The number of Conventional Commercial Banks experienced a gradual decline, decreasing from 107 banks in 2021 to 105 banks in both 2023 and 2024, a reduction of approximately 1.87%. Conversely, the number of Islamic Commercial Banks demonstrated consistent growth, rising from 12 banks in 2021 to 14 banks in 2024, representing an average growth rate of 5.34%.

These contrasting trends indicate that Islamic Commercial Banks have achieved relatively consistent growth amidst evolving competitive dynamics. In this context, both Conventional and Islamic Commercial Banks must demonstrate optimal performance. Strong performance depends on the effective management of input factors to generate maximum output (Badruzaman, 2020).

Bank performance can be assessed using various parameters, one of which is efficiency. Efficiency is a performance measure that considers the alignment between the costs incurred and the results achieved (Berger & Humphrey, 1997). In evaluating efficiency, banks are expected to utilise the minimum level of inputs while attaining the optimal level of outputs. To analyse efficiency in evaluating the performance of both bank types, the non-parametric Data Envelopment Analysis (DEA) approach can be employed. Unlike parametric methods, DEA does not require the normality assumption in its measurement (Susila et al., 2024). Through this approach, efficiency analysis can provide deeper insights into the factors that prevent a bank from achieving a full efficiency score of 1.00, which would otherwise indicate optimal operations (Riani & Hendrawan, 2020).

While DEA-based comparisons of BUK and BUS in Indonesia are not new, the existing body of evidence remains fragmented across four dimensions. First, most prior comparisons cover pre-pandemic or partial post-pandemic windows (e.g., 2014–2018, 2015–2019, 2020–2022), so the consolidated 2020–2024 post-pandemic recovery period has not yet been jointly evaluated. Second, several studies rely on a single DEA specification (either CRS or VRS), which constrains the ability to separate pure technical from scale inefficiency. Third, the use of a formal non-parametric inferential test to confirm or reject group differences is inconsistently applied. Fourth, sample composition is frequently limited to large or state-owned banks, omitting full representation across the KBMI 1–4 core capital tiers. The present study addresses these dimensions simultaneously and is therefore best framed as an updated empirical reassessment of BUK–BUS efficiency dynamics rather than as a wholly novel research design.

Literature Review

Efficiency in banking refers to an institution's capacity to maximise output generation from a given set of inputs while containing operational costs (Ascarya & Yumanita, 2006). Within the Indonesian banking landscape, efficiency serves as a critical benchmark for institutional competitiveness, regulatory soundness, and long-term financial sustainability. Among the available measurement frameworks, Data Envelopment Analysis (DEA) is one of the most extensively adopted due to its non-parametric nature and ability to handle multiple inputs and outputs without requiring a functional form specification. The CRS model was initially proposed by Charnes et al. (1978) and subsequently extended by Banker et al. (1984) to account for Variable Return to Scale (VRS) conditions. By constructing an empirical efficiency frontier, DEA identifies high-performing Decision Making Units (DMUs) and quantifies the adjustments required by underperforming units to attain efficiency (Hadad et al., 2003; Rusydiana & As-Salafiyah, 2021).

DEA-based research in Indonesia's banking industry spans diverse contexts and time frames. Studies on conventional banks, such as those by Cahyadi et al. (2018), Ersangga & Atahau (2019), Kusumaningsih et al. (2023) typically employ the intermediation approach, using inputs such as third-party funds (DPK), capital, and operational costs, with outputs such as loans and operating income. These works reveal varying efficiency patterns, with some state-owned banks consistently achieving optimal scores while others show fluctuating performance, underscoring the role of cost control and capital management.

Research focusing on Islamic banks, including Devi et al. (2022), Lestari & Huda (2020), and Rasyid Rabbani & Fitri (2024), commonly applies both CRS and VRS models to assess technical efficiency. While several Islamic banks demonstrated consistent efficiency in specific years, many experienced variability, suggesting that resource utilisation within the Sharia banking segment remains uneven across institutions. Firdaus & Hosen (2014) and Muharam & Pusvitasari (2007) found similar patterns using two-stage DEA and standard DEA respectively, confirming persistent challenges in achieving full efficiency.

Comparative studies between Islamic and conventional banks (Aisyah & Bakhtiar, 2024; Amalia & Fitri, 2018; Hadini & Wibowo, 2021; Ifanda Akbar & Wuryani, 2018; Sari & Nuwailah, 2022; Yusuf et al., 2021) frequently report no statistically significant differences in efficiency under most DEA specifications. The COVID-19 pandemic introduced a further dimension: (Sholihah, 2021) documented efficiency declines in both bank types during 2019–2020, with Islamic banks exhibiting greater resilience. Cross-country perspectives, such as Hibatullah & Nurcahyani (2021)comparing Islamic banks in Indonesia and Saudi Arabia, Rani & Kassim (2020) examining intertemporal DEA efficiency in Indonesia and Malaysia, and Abdullah et al. (2019) examining Malaysian Islamic banks, illustrate that contextual factors shape efficiency outcomes as much as internal resource allocation strategies (Ascarya & Yumanita, 2009).

From a regional perspective, Chowdhury & Haron (2021) evaluated 31 Islamic banks across Southeast Asia using DEA and the Malmquist Productivity Index (2014–2019), documenting gradual productivity improvements in Indonesia while noting significant efficiency variability across markets. Synthesising across these studies, DEA proves to be a robust framework for evaluating bank efficiency in varying institutional contexts. Structural characteristics such as ownership type or Sharia versus conventional orientation do not consistently produce significant efficiency differentials; rather, managerial and operational practices—particularly cost efficiency, capital utilisation, and asset productivity—are critical determinants of performance (Christianti, 2021; Hardianto & Wulandari, 2016).

Against this backdrop, the present study undertakes a systematic comparison of efficiency performance between BUK

Table 1. Development of the Number of Conventional Commercial Banks (BUK) and Islamic Commercial Banks (BUS) in Indonesia, 2021–2024

	2021	2022	2023	2024
Conventional Commercial Banks (BUK)	107	106	105	105
Islamic Commercial Banks (BUS)	12	13	13	14

Source: OJK (2025)

and BUS in Indonesia, applying DEA under both CRS and VRS specifications across the 2020–2024 period. A formal Mann–Whitney U test is further employed to determine whether the two bank categories differ significantly in their efficiency outcomes under each specification.

Methods

Research Type

A quantitative comparative design underpins this research. Secondary data drawn from audited annual financial reports are subjected to rigorous statistical procedures to evaluate and contrast efficiency performance between BUK and BUS in Indonesia across the 2020–2024 observation period. The study is grounded in a positivistic paradigm, with empirical hypothesis testing conducted via established non-parametric techniques.

Population and Sample

The research population encompasses all Conventional and Islamic Commercial Banks formally licensed and supervised by the Financial Services Authority (OJK) of Indonesia during the 2020–2024 period. A purposive sampling procedure was employed to ensure representativeness and data completeness across both banking categories. The inclusion criteria comprised: (1) institutional classification as a Conventional or Islamic Commercial Bank, thereby excluding Sharia Business Units (UUS), Rural Banks (BPR), and Sharia Rural Financing Banks (BPRS); (2) uninterrupted OJK registration throughout the full five-year observation window; (3) no mergers, acquisitions, or operational reclassifications during the study period; (4) availability of complete and auditable annual financial reports covering all designated input and output variables; and (5) representation across all capital-tier business activity groups (KBMI 1–4). Application of these criteria yielded a final sample of 11 BUK and 5 BUS, as detailed in Table 2.

The smaller Islamic banking sample (n = 5) reflects two structural realities of the Indonesian dual banking system rather than a sampling preference. First, the population of BUS is itself small: only 12–14 BUS operated during 2020–2024, compared with 105–107 BUK. Second, several BUS that were active during part of the window were excluded by the no-merger criterion (most notably the 2021 BSI consolidation of BRI Syariah, BNI Syariah, and Mandiri Syariah), and a further subset did not span the entire five-year window with complete and continuously available audited reports. The resulting 11:5 imbalance is therefore a near-census of eligible BUS rather than an arbitrary truncation; this is explicitly accounted for through the use of the Mann–Whitney U test, which tolerates unequal group sizes, and is also flagged in the Limitations section because it nonetheless constrains the statistical power of VRS-based inferences.

Research Location

This study was conducted at the national level in Indonesia, examining banks operating under the dual banking regulatory framework supervised by OJK. Data were obtained from publicly accessible annual financial reports and OJK's official banking statistics portal. The national scope was selected to ensure adequate representation of both bank categories across different KBMI groups and to capture the overall efficiency dynamics of Indonesia's banking system during the post-pandemic recovery period.

Instrumentation or Tools

Three software packages underpinned the empirical work: (1) MaxDEA (version 8.0) for estimating DEA efficiency scores under CRS and VRS specifications; (2) IBM SPSS Statistics (version 25) for conducting normality diagnostics via Shapiro–Wilk and group comparison via Mann–Whitney U; and (3) Microsoft Excel for data organisation, cleansing, and preparation prior to analysis. The DEA framework adopts an output-oriented intermediation approach, selected because it directly mirrors the core operational logic of banks under both regulatory regimes—transforming deposits and capital into financing or credit—and is therefore the most widely applied approach in comparative bank-efficiency research (Hadad et al., 2003).

Data Collection Procedures

Secondary data were collected from the annual financial reports of each sampled bank for the years 2020 to 2024. These reports were accessed through OJK's official banking statistics portal and individual bank websites. Data collection focused on eight variables: four input variables (total assets, operating expenses, third-party funds/DPK, and capital) and four output variables (loans or financing, interest income or profit-sharing, net income, and operating income). All monetary values are reported in millions of Indonesian Rupiah (IDR) and were standardised to the same unit of measurement prior to analysis. Data were verified for consistency across reporting periods and cross-referenced with OJK's Statistik Perbankan Indonesia to ensure accuracy.

The selection of inputs and outputs follows the intermediation approach to bank efficiency Berger & Humphrey (1997). Total assets, operating expenses, third-party funds (DPK), and capital are treated as inputs because they represent the principal financial and operational resources mobilised by banks to perform intermediation. Loans/financing, interest income or profit-sharing, net income, and operating income are treated as outputs because they capture the principal results of the intermediation process. This input–output specification is consistent with prior Indonesian DEA studies (Cahyadi et al., 2018; Devi et al., 2022; Ersangga & Atahau, 2019; Lestari & Huda, 2020) and is symmetrically applicable to BUK and BUS once profit-sharing income is treated as the Sharia analogue of interest income.

Data Analysis

The empirical analysis proceeded through three ordered stages, each directly linked to the research question of whether BUK and BUS differ in efficiency under CRS and VRS specifications. First, efficiency scores were estimated via MaxDEA for each bank-year observation under both the CRS and VRS frameworks. The CRS specification Charnes et al. (1978) treats all decision-making units as operating at their most productive scale, while the VRS specification Banker et al. (1984) introduces a convexity restriction ($\Sigma\lambda = 1$) to accommodate scale variations across banks. A unit attaining a score of 1.00 operates at the efficiency frontier; any score below 1.00 reflects a degree of technical inefficiency. The CRS–

Table 2. Research Samples

Conventional Commercial Banks (BUK)	Islamic Commercial Banks (BUS)
Bank Mandiri	Bank Muamalat Indonesia
Bank Pan Indonesia (Panin)	Bank Mega Syariah
Bank Central Asia (BCA)	Bank Panin Dubai Syariah
Bank Negara Indonesia (BNI)	Bank BTPN Syariah
Bank Rakyat Indonesia (BRI)	Bank Jabar Banten Syariah Indonesia
Bank CIMB Niaga	
Bank OCBC NISP	
Bank BJB	
Bank Maybank Indonesia	
Bank Mega	
Bank Danamon	

Source: OJK (2025)

VRS gap is interpreted as scale inefficiency, while the VRS score isolates pure technical efficiency.

Second, distributional assumptions were evaluated using the Shapiro–Wilk test applied to the computed efficiency scores. A significance value exceeding 0.05 would support the use of a parametric independent-samples t-test; a value at or below 0.05 would require a non-parametric equivalent. Third, the Mann–Whitney U test was used to determine whether a statistically significant difference exists between the efficiency levels of BUK and BUS under each specification at a significance level of $\alpha = 0.05$. If the Asymp. Sig. (2-tailed) > 0.05, the null hypothesis (H_0: no significant difference) is retained; if Asymp. Sig. < 0.05, H_0 is rejected.

Result and Discussion

This section is organised in three subsections that mirror the analytical stages described above. Subsection 4.1 reports the descriptive profile of inputs and outputs. Subsection 4.2 reports DEA efficiency outcomes under CRS and VRS. Subsection 4.3 reports inferential test results (Shapiro–Wilk and Mann–Whitney U). Interpretive comparison with prior studies is reserved for the Discussion.

Descriptive Statistics of Inputs and Outputs

Tables 3 and 4 summarise the descriptive statistics for BUK and BUS over the 2020–2024 window. All monetary values are reported in millions of IDR to ensure direct comparability between the two groups.

Table 3 shows that BUK exhibit substantial within-group heterogeneity. Total assets range from approximately IDR 112 trillion to IDR 2,427 trillion, with a mean of IDR 685 trillion and a standard deviation of IDR 688 trillion. Operating expenses range from IDR 3.0 trillion to IDR 83.1 trillion. Third-party funds (DPK) range from IDR 79.2 trillion to IDR 1,446.2 trillion. Capital ranges from IDR 12.0 trillion to IDR 323.2 trillion. On the output side, loans range from IDR 16.0 trillion to IDR 1,573.9 trillion, interest income from IDR 8.0 trillion to IDR 185.3 trillion, net income from IDR 1.1 trillion to IDR 61.2 trillion, and operating income from IDR 288 billion to IDR 53.9 trillion.

Table 4 reports the BUS descriptive statistics on the same unit basis as Table 3 (millions IDR). The mean asset value for BUS is approximately IDR 2.59 trillion, which is substantially smaller than the BUK mean of IDR 685 trillion. The maximum asset value for BUS (IDR 16.6 trillion) is also far below the BUK maximum (IDR 2,427 trillion). High standard deviations across all BUS variables indicate considerable scale heterogeneity within the Islamic banking sample. Two implications follow: first, the pronounced size gap between BUK and BUS justifies estimating efficiency under both CRS and VRS, since the CRS assumption is particularly sensitive to scale dispersion; second, the descriptive evidence already signals that any subsequent efficiency comparison is inherently a comparison between groups of markedly different scale.

DEA Efficiency Outcomes (CRS and VRS)

Efficiency scores under both CRS and VRS specifications were derived for each bank-year observation. A unit attaining a score of 1.00 operates on the efficiency frontier; values below 1.00 reflect proportional deviations from the efficient benchmark.

Table 5 reports the CRS-based efficiency scores for BUK. Two banks—BJB and Bank Mega—maintained full efficiency (score = 1.00) throughout the entire five-year window. Mandiri, BCA, BNI, BRI, and Danamon achieved full efficiency in 2023 and 2024, reflecting improvement over the period. CIMB Niaga displayed the lowest CRS performance among all BUK, with scores consistently below 1.00 throughout 2020–2024 (range: 0.79–0.90). The overall mean CRS efficiency score for BUK was 0.96.

Under the VRS specification (Table 6), BJB and Bank Mega again maintained perfect efficiency throughout the observation period. Mandiri, BCA, BNI, and Maybank displayed fluctuating efficiency levels but achieved full efficiency in later years. CIMB Niaga improved over the period yet did not reach full efficiency in any year. The overall mean VRS efficiency score for BUK was 0.97, only marginally higher than the CRS score (0.96), indicating that for BUK the difference between technical and scale inefficiency is modest.

Table 7 reports the CRS scores for BUS. Bank Panin Dubai Syariah consistently achieved full efficiency in 2020, 2021, 2022, and 2024, with only a marginal decline to 0.99 in 2023. Bank Muamalat Indonesia recorded the lowest CRS score of

Table 3. Descriptive Statistics of Conventional Commercial Banks (BUK), 2020–2024 (in millions IDR)

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Assets	55	112,202,653	2,427,223,262	685,342,431	688,237,312
Operating Expenses	55	3,037,544	83,116,426	21,246,141	22,649,141
Third-party Funds (DPK)	55	79,186,302	1,446,234,957	455,725,740	455,347,799
Capital	55	12,005,800	323,189,047	104,425,087	101,372,596
Loans/Financing	55	15,985,784	1,573,861,967	387,349,081	403,646,186
Interest Income/Profit-sharing	55	8,046,281	185,272,091	43,700,530	46,217,531
Net Income	55	1,088,942	61,165,121	15,110,316	19,280,762
Operating Income	55	288,030	53,857,740	12,505,062	14,979,776
Valid N (listwise)	55				

Source: SPSS output processed by authors (2025)

Table 4. Descriptive Statistics of Islamic Commercial Banks (BUS), 2020–2024 (in millions IDR)

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Assets	25	8,884	16,641,459	2,586,222	5,351,967
Operating Expenses	25	208	485,548	78,849	163,429
Third-party Funds (DPK)	25	480	3,574,369	514,000	1,114,205
Capital	25	1,208	3,180,785	593,697	1,208,344
Loans/Financing	25	3,972	9,277,902	1,387,619	2,902,058
Interest Income/Profit-sharing	25	676	1,089,964	165,194	343,149
Net Income	25	0.13	183,745	24,751	53,586
Operating Income	25	44	70,673	10,003	20,775
Valid N (listwise)	25				

Source: SPSS output processed by authors (2025)

0.78 in 2024, despite having reached full efficiency in 2020. Bank BTPN Syariah remained persistently inefficient throughout the entire observation period (range: 0.83–0.88). The overall mean CRS efficiency score for BUS was 0.93, below the BUK average of 0.96.

Under the VRS specification (Table 8), Bank Panin Dubai Syariah, Bank BTPN Syariah, and Bank Jabar Banten Syariah consistently maintained full efficiency throughout the entire observation period. Bank Muamalat Indonesia and Bank Mega Syariah exhibited inefficiency in certain years. The annual mean reached 1.00 in both 2023 and 2024, with an overall mean of 0.99—substantially higher than the CRS mean of 0.93. The wide CRS–VRS gap for BUS (0.93 vs. 0.99) is the largest in the dataset and indicates that a considerable portion of BUS inefficiency under CRS is attributable to scale, not to pure technical (managerial) inefficiency.

Inferential Tests (Normality and Mann–Whitney U)

Before selecting the comparative statistical procedure, the distributional properties of the efficiency scores were examined via the Shapiro–Wilk diagnostic. A p-value above 0.05 would support a parametric approach, while a lower value would direct analysis toward a non-parametric alternative.

Table 9 shows that all significance values were below 0.001 for both bank groups and under both DEA specifications. The rejection of normality confirmed that parametric comparison was unsuitable, and the Mann–Whitney U procedure was selected as the appropriate non-parametric method.

Group differences in efficiency scores between BUK and BUS were then formally assessed using the Mann–Whitney U procedure, with a significance threshold of $\alpha = 0.05$ applied across both specifications. Tables 10–11 report the CRS comparison; Tables 12–13 report the VRS comparison.

Table 10 shows that under CRS, BUK recorded a mean rank of 42.71 while BUS recorded a mean rank of 35.64, indicating marginally higher CRS efficiency for BUK on average.

Table 11 reports an asymptotic significance of 0.194, exceeding the 0.05 threshold. H_0 is therefore retained: the evidence does not support a statistically significant CRS efficiency gap between BUK and BUS.

Table 12 shows that under VRS, BUK recorded a mean rank of 36.88 while BUS recorded a higher mean rank of 48.46, indicating that BUS demonstrates higher pure technical efficiency under the VRS specification.

Under the VRS specification, Table 13 reports an asymptotic significance of 0.018, below the 0.05 boundary. H_0 is rejected: a statistically significant efficiency differential exists between BUK and BUS under variable scale conditions, with BUS achieving higher mean ranks.

Interpretation of Key Findings

Three findings emerge directly from the empirical analysis. First, under CRS, BUK recorded a mean efficiency score of 0.96 and BUS recorded 0.93; neither group reached the frontier. Second, under VRS, the two means converged toward the frontier (BUK = 0.97, BUS = 0.99). Third, the Mann–Whitney U test rejected H_0 only under VRS (Asymp. Sig. = 0.018), not under CRS (Asymp. Sig. = 0.194). The remainder of this subsection unpacks what these results directly support and what they do not.

From an intermediation-theory perspective Berger & Humphrey (1997), the persistent CRS inefficiency in both groups reflects a misalignment between the volume of intermediation inputs mobilised—total assets, operating expenses, third-party funds, and capital—and the corresponding intermediation outputs—loans/financing, interest or profit-sharing income, net income, and operating income. The dominant slack patterns observed in MaxDEA

Table 5. Efficiency Levels of Conventional Commercial Banks (BUK) — CRS Approach, 2020–2024

Banks	2020	2021	2022	2023	2024
Mandiri	0.96	0.91	0.94	1.00	1.00
Pan Indonesia	1.00	0.97	0.96	0.98	0.95
BCA	0.90	0.87	0.90	0.94	1.00
BNI	0.95	0.90	0.93	0.96	1.00
BRI	0.97	0.91	0.94	0.96	1.00
CIMB Niaga	0.79	0.82	0.89	0.90	0.90
OCBC NISP	1.00	0.94	0.97	1.00	1.00
BJB	1.00	1.00	1.00	1.00	1.00
Maybank Indonesia	0.93	0.87	1.00	0.94	0.91
Mega	1.00	1.00	1.00	1.00	1.00
Danamon	1.00	0.94	0.94	1.00	1.00
Annual Average	0.95	0.92	0.95	0.97	0.98
Total Average	0.96				

Source: MaxDEA output processed by authors (2025)

Table 6. Efficiency Levels of Conventional Commercial Banks (BUK) — VRS Approach, 2020–2024

Banks	2020	2021	2022	2023	2024
Mandiri	0.96	0.91	0.94	1.00	1.00
Pan Indonesia	1.00	1.00	0.99	1.00	0.96
BCA	0.96	0.98	0.99	0.96	1.00
BNI	0.97	0.90	0.93	0.97	1.00
BRI	1.00	0.91	0.94	1.00	1.00
CIMB Niaga	0.82	0.84	0.92	0.93	0.93
OCBC NISP	1.00	0.96	0.98	1.00	1.00
BJB	1.00	1.00	1.00	1.00	1.00
Maybank Indonesia	0.95	0.93	1.00	1.00	1.00
Mega	1.00	1.00	1.00	1.00	1.00
Danamon	1.00	0.98	0.99	1.00	1.00
Annual Average	0.97	0.95	0.97	0.99	0.99
Total Average	0.97				

Source: MaxDEA output processed by authors (2025)

Table 7. Efficiency Levels of Islamic Commercial Banks (BUS) — CRS Approach, 2020–2024

Banks	2020	2021	2022	2023	2024
Bank Muamalat Indonesia	1.00	0.82	0.96	0.83	0.78
Bank Mega Syariah	0.87	1.00	0.84	1.00	1.00
Bank Panin Dubai Syariah	1.00	1.00	1.00	0.99	1.00
Bank BTPN Syariah	0.86	0.83	0.84	0.87	0.88
Bank Jabar Banten Syariah	0.96	0.95	0.90	0.98	1.00
Annual Average	0.94	0.92	0.91	0.93	0.93
Total Average	0.93				

Source: MaxDEA output processed by authors (2025)

outputs (excess assets, operational costs, and DPK) suggest that both bank types absorbed more funds and incurred higher operating costs than were required to produce their observed output bundles. This is consistent with the input-slack interpretation routinely documented in Indonesian DEA studies (Berger & Humphrey, 1997; Hadad et al., 2003).

The more analytically informative comparison is between the CRS and VRS scores. By construction, the CRS–VRS gap isolates scale inefficiency, while the VRS score isolates pure technical (managerial) efficiency. For BUK the CRS–VRS gap is small (0.96 vs. 0.97), implying that BUK inefficiency is predominantly managerial rather than scale-related. For BUS the gap is much larger (0.93 vs. 0.99), implying that the bulk of BUS inefficiency under CRS is attributable to operating away from the optimal scale rather than to managerial shortcomings. This scale-related constraint is consistent with patterns documented across KBMI bank groups in Indonesia, where smaller-tier banks consistently demonstrate greater scale sensitivity relative to KBMI 3–4 institutions (Ischak et al., 2024).

It is therefore important not to over-interpret the significant VRS result. The Mann–Whitney U rejection under VRS (BUS mean rank 48.46 vs. BUK 36.88) is direct statistical evidence of a scale-adjusted (pure technical) efficiency advantage for BUS once the constant-scale constraint is removed. It is not, however, evidence that BUS outperform BUK in overall operational terms. Two specific cautions follow. First, the CRS result—which does correspond to overall technical efficiency—is statistically non-significant, so any claim of broad operational superiority for BUS is not supported by the data. Second, the VRS frontier is defined locally for each scale, so a BUS achieving a VRS score of 1.00 is efficient relative to other small banks at a similar scale, not relative to BUK operating at a vastly larger scale.

Comparison with Previous Studies

The CRS finding of no significant efficiency difference between BUK and BUS confirms the converging evidence of several prior Indonesian studies. (Aisyah & Bakhtiar, 2024), examining the 2020–2022 period, similarly found no significant difference using DEA under comparable specifications. Ifanda Akbar & Wuryani (2018) and Sari & Nuwailah (2022) reached the same conclusion across different periods. The present study extends this body of evidence by showing that the absence of a significant CRS gap persists across the full 2020–2024 window, including the post-pandemic recovery years that earlier studies did not yet cover.

The significant VRS result, by contrast, contributes a more nuanced finding to the literature. It is broadly consistent with Riani & Hendrawan (2020), who found Islamic banks to be more efficient than conventional banks in certain specifications, and with Sholihah (2021), who documented that Islamic banks exhibited greater resilience and smaller efficiency losses during the COVID-19 period (2019–2020). Ikhwan & Riani (2023), applying DEA Window Analysis to Islamic banks in Indonesia and Malaysia (2017–2022), reported that Islamic-bank efficiency remained stable through the pandemic, suggesting a degree of structural robustness that may carry into the post-pandemic period. The present VRS evidence is consistent with this trajectory, but the present study adds a formal inferential test under both specifications, which is largely absent from these earlier works.

At the same time, the VRS finding contradicts—or at least qualifies—evidence from other Indonesian studies. Amalia & Fitri (2018) and Hadini & Wibowo (2021) found no significant VRS difference. Chabachib et al. (2019) and Hardianto & Wulandari (2016) documented that Islamic banks may lag conventional banks in certain operational dimensions. A recent study by Kamarni et al. (2025), employing Stochastic Frontier Analysis (SFA), found that conventional banks in Indonesia exhibit consistently higher and more stable efficiency scores, though SFA captures cost-efficiency dimensions beyond the scope of DEA-based technical efficiency. These discrepancies likely reflect three sources of variation:

Table 8. Efficiency Levels of Islamic Commercial Banks (BUS) — VRS Approach, 2020–2024

Banks	2020	2021	2022	2023	2024
Bank Muamalat Indonesia	1.00	0.94	1.00	1.00	0.98
Bank Mega Syariah	0.89	1.00	0.85	1.00	1.00
Bank Panin Dubai Syariah	1.00	1.00	1.00	1.00	1.00
Bank BTPN Syariah	1.00	1.00	1.00	1.00	1.00
Bank Jabar Banten Syariah	1.00	1.00	1.00	1.00	1.00
Annual Average	0.98	0.99	0.97	1.00	1.00
Total Average	0.99				

Source: MaxDEA output processed by authors (2025)

Table 9. Shapiro–Wilk Normality Test Results

	Bank Type	Statistic	df	Sig.
CRS	BUK	0.840	55	< 0.001
CRS	BUS	0.834	25	< 0.001
VRS	BUK	0.726	55	< 0.001
VRS	BUS	0.429	25	< 0.001

Source: SPSS output processed by authors (2025)

Table 10. Mann–Whitney Test — Ranks of BUK and BUS Efficiency under CRS Assumption, 2020–2024

	Bank Type	N	Mean Rank	Sum of Ranks
CRS	BUK	55	42.71	2349.00
CRS	BUS	25	35.64	891.00
CRS	Total	80		

Source: SPSS output processed by authors (2025)

Table 11. Mann–Whitney Test Statistics — CRS

Mann–Whitney U	566.000
Wilcoxon W	891.000
Z	–1.300
Asymp. Sig. (2-tailed)	0.194

Source: SPSS output processed by authors (2025)

Table 12. Mann–Whitney Test — Ranks of BUK and BUS Efficiency under VRS Assumption, 2020–2024

	Bank Type	N	Mean Rank	Sum of Ranks
VRS	BUK	55	36.88	2028.50
VRS	BUS	25	48.46	1211.50
VRS	Total	80		

Source: SPSS output processed by authors (2025)

Table 13. Mann–Whitney Test Statistics — VRS

Mann–Whitney U	488.500
Wilcoxon W	2028.500
Z	–2.376
Asymp. Sig. (2-tailed)	0.018

Source: SPSS output processed by authors (2025)

(a) differences in the observation window (pre-pandemic vs. post- pandemic), (b) differences in sample composition (size of the BUS sample, inclusion of UUS, KBMI coverage), and (c) the methodological distinction between DEA technical efficiency and SFA cost efficiency. The present study's scale-adjusted advantage for BUS should therefore be read as a specification-conditional finding, not as a universal claim.

Cross-country evidence from Hibatullah & Nurcahyani (2021), comparing Indonesian and Saudi Arabian Islamic banks, and Abdullah et al. (2019) examining Malaysian Islamic banks, further illustrates that contextual regulatory and market factors substantially influence DEA efficiency outcomes, reinforcing the need for country-specific and time-specific analyses.

Contribution to Literature

Read against this prior evidence, the present study makes four cumulative contributions. First, it provides an updated empirical reassessment of BUK–BUS efficiency for the consolidated 2020–2024 post-pandemic window, which earlier Indonesian DEA studies (typically ending in 2018, 2019, 2020, or 2022) have not yet covered. Second, by estimating efficiency jointly under CRS and VRS specifications and applying the Mann–Whitney U test to each, it formally separates the question of overall technical efficiency (CRS) from that of pure technical or scale-adjusted efficiency (VRS), thereby avoiding the interpretive ambiguity present in single-specification studies. Third, the inclusion criterion of representation across all KBMI 1–4 capital tiers ensures that the BUK sample is not confined to the largest state-owned banks—a common limitation in prior comparative studies. Fourth, by identifying that the BUS advantage is statistically discernible only under VRS, the study offers new empirical support for the broader theoretical proposition that Islamic-bank inefficiency in Indonesia is predominantly scale-driven rather than managerial, with direct implications for the design of consolidation, KBMI tiering, and capital-strengthening policies for the Islamic banking segment.

Theoretical Implication

Beyond the descriptive comparison, the scale-versus-managerial decomposition has a clear theoretical implication for the financial-intermediation literature. If the dominant source of BUS inefficiency is scale rather than management, then interventions targeting managerial practices alone (training, governance reforms, operational risk frameworks) are unlikely to fully close the efficiency gap. The binding constraint is the mismatch between the scale at which BUS currently operate and the productive scale implied by the underlying intermediation technology. This is consistent with the structural reading of Banker et al. (1984) and with empirical KBMI-tier evidence from Ischak et al. (2024) that scale sensitivity is concentrated in lower-tier banks. The policy corollary—taken up explicitly in the Conclusion—is that scale-relevant levers (capital strengthening, balance-sheet expansion through Sharia-compliant instruments, and selective consolidation) are likely to be more efficiency-enhancing for BUS than managerial levers alone.

Limitations and Cautions

The study carries several methodological boundaries that warrant recognition. First and most importantly, the BUS sample is small (n = 5 banks, 25 bank-year observations). Although this is close to a census of BUS that satisfy the inclusion criteria, it materially reduces the statistical power of the VRS-based Mann–Whitney U test and constrains the external validity of VRS-based conclusions. Readers should therefore interpret the significant VRS result with corresponding caution, particularly when extrapolating to BUS that were excluded by the merger or data-completeness criteria.

Second, DEA rankings are sensitive to the choice of input and output variables. The intermediation specification employed here is well established and consistent with prior Indonesian studies, but alternative specifications—production-based, profit-based, or value-added approaches—could plausibly produce different rankings, especially for BUS where profit-sharing arrangements and off-balance-sheet items are less perfectly captured by intermediation-style outputs. Robustness checks under alternative variable sets would therefore strengthen comparative inferences.

Third, the panel structure of the dataset, while suitable for observing trends over time, does not permit causal attribution regarding efficiency drivers; subsequent research may benefit from second-stage Tobit models or dynamic panel estimators to identify key explanatory factors (Firdaus & Hosen, 2014). Fourth, the unequal group sizes (55 vs. 25 observations) are tolerated by the Mann–Whitney U procedure but remain an additional reason to treat VRS comparisons cautiously.

Recommendations for Future Research

Addressing these constraints in follow-up studies would strengthen the robustness of efficiency comparisons in the Indonesian banking sector. Specifically, future research could: (a) extend the observation window beyond 2024 and pair it with dynamic panel estimators to capture efficiency trends across full economic cycles; (b) enlarge the Islamic banking sample by incorporating Sharia Business Units (UUS) under appropriate methodological controls, which would raise the reliability of BUS-focused inferences; (c) introduce second-stage regression models incorporating macroeconomic, regulatory, and institution-specific variables (Fakhrunnas, 2018; Muharam & Pusvitasari, 2007); (d) cross-validate DEA estimates with stochastic frontier analysis or hybrid approaches; and (e) integrate sustainability dimensions—such as environmental, social, and governance (ESG) indicators—into future efficiency frameworks to align with the growing relevance of responsible finance within Indonesia's Islamic banking ecosystem.

Conclusion

This study compared the technical efficiency of Conventional and Islamic Commercial Banks in Indonesia over the post-pandemic recovery window 2020–2024, applying DEA under both CRS and VRS specifications and complementing the descriptive scores with a Mann–Whitney U group comparison.

The main comparative takeaway is twofold. There is no statistically significant difference in overall technical efficiency (CRS) between the two bank groups, confirming the converging evidence of earlier Indonesian studies and extending it into the post-pandemic period. There is, however, a statistically significant scale-adjusted (VRS) efficiency advantage for Islamic Commercial Banks. Read together, these two results indicate that the residual inefficiency of BUS observed under CRS is largely scale-driven rather than managerial.

The practical implications are correspondingly specific. For BUS, the policy lever most likely to close the remaining efficiency gap is scale-relevant rather than managerial: continued capital strengthening, expansion of Sharia-compliant balance-sheet instruments, and selective consolidation within the KBMI framework would all help BUS operate closer to their productive scale. For BUK, where the CRS–VRS gap is small, the more impactful levers are operational—containment of operating expenses, more productive deployment of DPK, and tighter alignment between asset growth and income generation. For OJK and policymakers, the evidence supports continued KBMI-aware supervision that differentiates expectations by scale tier and

recognises that the two bank groups face efficiency constraints of structurally different origins.

The principal limitation of the study is the small BUS sample (n = 5 banks, 25 bank-year observations), which constrains the statistical power of VRS-based inferences and the external validity of the scale-adjusted advantage identified for BUS. Future studies that extend the observation window, broaden KBMI-group coverage, incorporate UUS, and triangulate DEA with stochastic frontier or second-stage panel techniques would help test the robustness of the present findings.

Author contributions

Denia Maulani was responsible for the study's conceptualisation, research design, data collection, statistical analysis, and preparation of the manuscript. Kusnadi contributed to conceptualisation, literature synthesis, academic supervision, and manuscript review and editing. All authors reviewed and gave final approval to the submitted version.

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