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Efficiency of Conventional Banks in Indonesia: A Data Envelopment Analysis Approach

Muhammad Ridho Sahputra[1], Shelly Prahadian Putri[1]

[1]*Sriwijaya University, Indonesia*

*) *Corresponding Email: ridhosahputra@fe.unsri.ac.id*

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ABSTRACT

The goal of this study is to find out the efficiency of conventional banks on the Indonesia Stock Exchange during the 2021–2024 period using Data Envelopment Analysis (DEA) with profit and production approaches through panel data regression. This research uses a quantitative explanatory approach with purposive sampling. The sample consists of 32 conventional commercial banks with 128 observations. The DEA profit approach uses assets, operating expenses, and equity as inputs and net income as output, while the production approach uses assets, equity, and operating expenses as inputs and loans, third-party funds, and fee-based income as outputs. The results show that the average efficiency score of the production approach is higher than the profit approach, at 0.866661 compared to 0.532803. Conventional commercial banks are more efficient in generating intermediation and service outputs than in generating net profit. Large-asset banks generally have higher efficiency scores than medium-asset banks. The regression results show that, in the profit approach, operating expenses have a significant negative effect on efficiency, while net income has a significant positive effect. Meanwhile, in the production approach, operating expenses have a significant positive effect, while fee-based income has a significant negative effect on efficiency. Assets and equity do not significantly affect efficiency in either approach. This study concludes that efficiency is more strongly reflected in production activities than in profit generation. Therefore, banks need to improve cost control, asset productivity, profit optimization, and the efficiency of service-based income to enhance overall banking efficiency.

A. INTRODUCTION

The banking sector remains the main source of financing for households, the business sector, and the productive sector; thus, banking efficiency is a key indicator in assessing the quality of financial intermediation. In this context, banks are not only required to grow in terms of assets, third-party funds, and loans, but must also be able to manage resources efficiently so that such growth generates optimal revenue and profits (Ul Hassan Shah et al., 2023). The Financial Services Authority reported that commercial bank loans grew by 10.92% year-on-year in October 2024, an increase compared to the same period the previous year of 8.99% year-on-year, while third-party funds grew by 6.74% year-on-year (Otoritas Jasa Keuangan, 2024). This growth in loans and third-party funds indicates that the intermediation function remains active; however, quantitative growth alone is insufficient to conclude that banks are operating efficiently. Efficiency requires further analysis because increases in inputs such as assets, equity, third-party funds, interest expenses, and operating expenses do not necessarily result in proportional outputs in the form of loans, interest income, fee-based income, and net profit.

Measuring banking efficiency is becoming increasingly important as the banking industry faces structural changes driven by digital transformation, competition from fintech, shifting customer preferences, and pressure to reduce costs. Digital transformation can

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enhance efficiency by accelerating service delivery, reducing transaction costs, expanding market reach, and improving operational productivity. However, digitalization can also increase costs related to technology investment, cybersecurity, system development, and organizational adjustments (Gherțescu et al., 2024). The diffusion of digital technology plays a crucial role in the process of efficiency convergence within the banking industry, as digitalization can assist less efficient financial institutions in bridging the performance gap with their more efficient counterparts (Liu et al., 2024). DEA is relevant to banking because banks are multi-product institutions that use various financial and operational inputs to generate diverse outputs such as loans, interest income, fee-based income, and profit. The DEA approach can be used to assess a bank's resource management efficiency and profitability efficiency because financial ratio-based measurements alone are often insufficient to capture the complexity of a bank's performance. Therefore, DEA is a relevant approach because it can measure a bank's relative efficiency within a multi-input and multi-output system (Istaiteyeh et al., 2024; Kweh et al., 2024).

(Yewisa & Satrianto, 2025) found that conventional commercial banks with large assets had higher average efficiency compared to banks with medium-sized assets during the 2019–2023 period. In 2023, large-asset banks recorded an average efficiency score of 0.7012, whereas medium-asset banks achieved only 0.2917, indicating a significant efficiency gap based on asset size. The study also showed that BCA and OCBC NISP ranked as efficient and functioned as reference points for alternative financial institutions. These findings suggest that asset size can be an important factor in explaining efficiency, but asset size alone is insufficient because some large banks also experienced fluctuations in efficiency from year to year. Another relevant study was conducted by (Nugraha et al., 2023) presented that the profit approach and the production approach can yield different efficiency classifications because they evaluate banks from distinct perspectives. The study also found that inefficiencies stem from suboptimal resource utilization in generating net profit, high labor costs, costs of goods and services, depreciation costs, education and training costs, maintenance costs, rental costs, and suboptimal strategies for shifting transactions to digital channels. However, the focus of this study is mainly on the branch network of a single Islamic bank, a single region, and a relatively short observation period.

Based on previous research, there are several research gaps that need to be addressed. First, some empirical studies on the efficiency of banking institutions in Indonesia still rely on a single DEA approach, such as using only the CRS method or treating net profit as the sole primary output. In fact, a bank may be efficient in performing its intermediation functions but not necessarily efficient in generating profit. Previous research has not fully incorporated asset size heterogeneity as a basis for more in-depth analysis (Hadi et al., 2025). (Yewisa & Satrianto, 2025) did compare bank efficiency based on asset groups, but the model used was still limited to DEA-CRS with net profit as the primary output. In fact, differences in assets can reflect differences in business scale, capital capacity, business networks, technology, and managerial capabilities. Therefore, research is needed that classifies banks based on asset size while comparing efficiency across two orientations: production and profit. Furthermore, many banking DEA studies still stop at measuring efficiency scores and bank rankings, thus failing to explain the factors influencing efficiency. (Ullah et al., 2023) indicate that banking efficiency may be affected by internal determinants, including governance mechanisms, ownership structure, leverage, bank size, and profitability. Thus, DEA analysis should be followed by a second-stage regression to determine whether capital, liquidity, credit risk, bank size, interest margins, and cost efficiency influence efficiency scores. Bank efficiency must also account for the credit risk dimension. High credit growth can increase a bank's output, but it can also increase risk if accompanied by a rise in non-performing loans. (Fukuyama et al., 2024) emphasize that modeling non-performing loans within a bank's production function is a critical issue because the presence of non-performing loans can affect estimates of bank inefficiency.

Based on this gap, this study offers several novelties. First, this study combines the DEA production and profit approach from 2021–2024. This novelty is important because not

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only viewed from the ability to generate profits but also from the bank's ability to perform intermediary functions and produce financial services. Second, this study classifies banks based on asset size to test whether differences in business scale explain variations in efficiency across banks. Third, this paper combines DEA efficiency with panel data regression to test the determinants of efficiency (Milenković et al., 2022). This period is used at 2021-2024 because it reflects the post-pandemic recovery phase, the normalization of credit restructuring, increased adoption of digital services, and banks' adjustment of operational strategies to new economic conditions (Zuo et al., 2021). With this timeframe, this study is expected to offer a more up-to-date image of the efficiency of conventional commercial banks in Indonesia compared to studies that only use data up to 2023 or focus on specific branch units. The main issue examined in this study is whether conventional commercial banks listed on the Indonesia Stock Exchange have used financial and operational inputs efficiently to generate intermediation outputs and profits. This issue is significant because banks with large assets are not necessarily efficient if they are unable to control costs, optimize lending, maintain asset quality, and generate profits proportionally. Conversely, banks with smaller assets can achieve efficiency if they are able to manage inputs more economically and generate optimal outputs (Jia & Liu, 2023).

B. THEORETICAL STUDY

The Theory of Efficiency

In the banking context, efficiency not only denotes a bank's capacity to make profits while also illustrating its proficiency in resource management, such as assets, equity, third-party funds, operating costs, and labor. The frontier approach is relevant because banks are compared relatively to other banks on the best frontier, rather than being evaluated based solely on a single financial ratio. (Kweh et al., 2024) assert that bank performance measurement based on financial ratios is often insufficient because banks are multi-product institutions that manage numerous inputs and outputs simultaneously; thus, the DEA approach is better suited to capture the efficiency of resource management and bank profitability. DEA does not require a specialised manufacturing function, which makes it acceptable for the banking business, which has complex operational structures and generates more than one type of output (Ullah et al., 2023). A bank with large assets is not necessarily efficient if its assets, equity, third-party funds, and operating costs cannot be converted into loans, revenue, and profit proportionally. Conversely, a bank with smaller assets can be considered efficient if it is able to generate relatively high output with limited inputs. Thus, efficiency in this study is understood as a relative concept, not an absolute one, because each bank is compared with other banks in the same observation group (Bueno et al., 2024).

Data Envelopment Analysis (DEA) in Measuring Bank Efficiency

DEA is a frequently utilised approach in banking efficiency study since it can handle several inputs and outputs concurrently. A bank's efficiency is calculated by comparing combinations of outputs against combinations of inputs, and then forming an efficiency frontier from the best-performing units. Banks located on the frontier are given a score of one, meanwhile those under the frontier are given less than one. DEA is applied through two approaches: the profit approach and the production approach. In the production approach, banks use inputs such as assets, equity, interest expenses, operating expenses, and labor costs to generate outputs including loans, third-party funds, interest income, and fee-based income. In the profit approach, banks are viewed as business entities that use resources and costs to generate net profit and operating income. This dual approach is necessary because banks that are productive in extending credit are not necessarily efficient in generating profit (Ullah et al., 2023).

Outputs in the production approach typically include non-interest income, loans, interest income, and deposits. This method aligns with the bank's role as an intermediary institution producing financial services (Fakhrunnas et al., 2018). (Mateev et al., 2023) note that the

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intermediation approach in DEA focuses on how banks raise capital and turn it into loans, making this approach relevant for assessing a bank's core functions. Distinguish between resource management efficiency and profitability efficiency when evaluating bank performance, as a bank may possess strong resource management capabilities but may not necessarily be able to convert them into optimal profitability. This distinction forms the basis for using two approaches in this study, as bank efficiency is not merely assessed by output volume but also by the ability to generate profit (Zhu & Wang, 2025). A crucial foundation for employing these two approaches, as it utilized the DEA production approach and profit approach and demonstrated that bank inefficiencies can stem from suboptimal cost allocation, resources that fail to generate maximum profit, and the need to shift transactions to digital channels. However, that study was conducted on the branch network of Bank Syariah Indonesia and covered a relatively short period.

Previous Research

Based on prior research, the DEA profit approach, asset classification, and panel data regression on conventional commercial banks listed on the IDX for the 2021–2024 period.

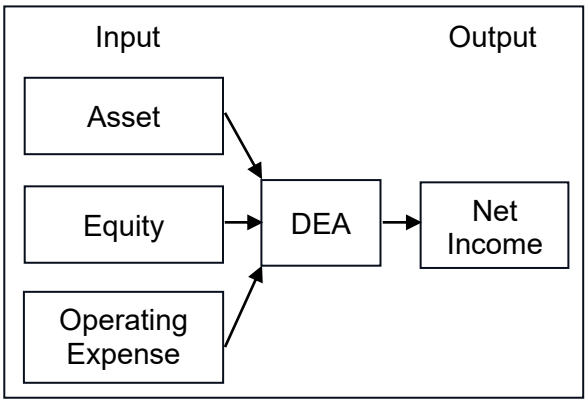

Figure 1a. Conceptual Framework Profit Approach

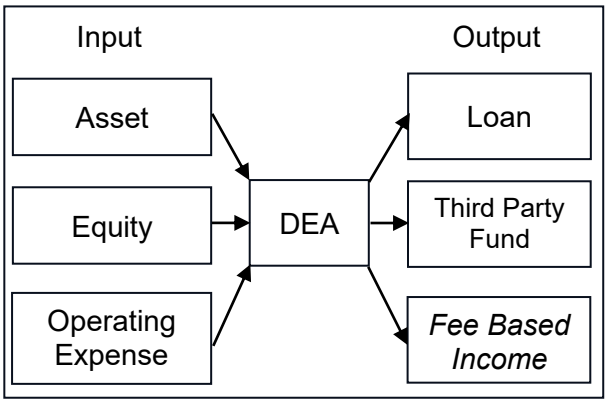

Figure 1b. Conceptual Framework Production Approach

Source: Data Processed, 2026

Table Operational Definitions of Variables

No	Variable	Definitions	Formulas	Scales
1	Asset	Tangible assets used by the bank for operational activities.	*Assets = Total Net Assets*	Ratio
2	Equity	The bank's net capital is calculated after assets are reduced by liabilities.	*Equity = Total Assets − Total Liabilities*	Ratio
3	Operating Expense	Expenses incurred by the bank to conduct operational activities.	*Operating Expenses = Total Operating Expenses*	Ratio
4	Loan	Funds disbursed by the bank to third parties in the form of loans.	*Loans Outstanding = Total Loans Outstanding*	Ratio
5	Third Party Fund	Public funds collected by the bank through checking accounts, savings accounts, and time deposits.	*Third Party Fund = Checking Accounts + Savings Accounts + Time Deposits*	Ratio
6	Fee-Based Income	Non-interest income from banking services.	*Fee-Based Income = Total Income from Fees, Commissions, and Other Services*	Ratio
7	Net Income	The bank's profit after deducting all expenses and taxes.	*Net Income = Before Tax − Tax Expense*	Ratio

Source: Data Processed, 2026

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a. **H1** and **H2**: Assets do not influence on efficiency scores with the production and profit approaches

Assets reflect a bank's physical and technological infrastructure capacity in supporting operational activities. Banks with optimally managed assets can generate intermediation output and profits more efficiently (Horvat et al., 2023). However, excessively large assets without adequate productivity can lead to cost inefficiencies. (Wang et al., 2024) demonstrate that operational efficiency is influenced by the bank's size, profitability, development capacity, and innovation, making assets and operational capacity relevant in explaining bank efficiency. In the study (Nugraha et al., 2023), assets were also used as inputs in DEA efficiency measurements and were linked to a bank's capacity to manage production output and profit. The outcome indicates that there is no significant impact between the asset variable and efficiency scores, as efficiency cannot be achieved without the ability to optimally convert inputs into outputs.

b. **H3** and **H4**: Equity do not influence on efficiency scores with the production and profit approaches

Equity reflects a bank's capital capacity to support business expansion, absorb risk, and strengthen intermediation activities. Banks with strong equity have greater scope to expand lending, strengthen customer trust, and generate profits (Henriques et al., 2020). However, large equity that is not used productively can reduce efficiency (Istaiteyeh et al., 2024) found that differences in bank efficiency can be explained by internal bank characteristics and differences in business scale, making capital and bank capacity important factors in efficiency. In a study (Nugraha et al., 2023), equity was used as one of the DEA inputs to measure bank efficiency, yielding insignificant results because a large funding structure is not necessarily productive if not managed optimally.

c. **H5** and **H6**: Operating expenses do not influence on efficiency scores with the production and profit approaches.

Operating expenses reflect the costs incurred by banks to conduct business activities. Efficient operating expenses can support increased output and profit, but high operating expenses without an increase in output will reduce efficiency (Gardijan Kedžo & Tuškan Sjauš, 2021). (Ullah et al., 2023) demonstrate that administrative costs are used as inputs in the DEA model to measure bank efficiency, making cost structure a critical component of banking efficiency. Research by (Nugraha et al., 2023) also found that bank inefficiency can be caused by high labor costs, costs of goods and services, depreciation costs, maintenance costs, and rental costs. However, (Blankson et al., 2022) operating expenses on efficiency is not always direct because efficiency depends on a bank's ability to convert costs into commensurate output.

d. **H7**: Loans influence on efficiency scores with the production approach.

Loans granted are the primary output in a bank's intermediation function. The more optimally a bank channels resources into productive loans, the greater the likelihood of achieving production efficiency (Tolesa Agama et al., 2023). However, loan disbursement without adequate asset quality can lead to credit risk. (Wang et al., 2024) emphasize that measuring bank efficiency must consider positive outputs such as loans and revenue, but also account for risks like non-performing loans. Additionally, (Venugopal, 2024) notes that loans granted reflect a bank's intermediation function, but increased lending doesn't guarantee efficiency if the quality and composition of the loan portfolio are suboptimal.

e. **H8**: Third-party influence on the efficiency scores with the production approach.

In the production approach, third-party funds can be viewed as output because they indicate the bank's success in providing fund-mobilization services. However, large amounts of third-party funds must be managed productively to enhance efficiency. (Nugraha et al., 2023) used third-party funds as output in the production approach and found no significant

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relationship between third-party funds and efficiency scores when using the production approach or the profit approach.

f. **H9**: Fee based income influence on the efficiency scores with the production approach.

Fee-based income reflects non-interest service revenue earned by banks from banking services, such as administration, commissions, fees, digital transactions, transfers, cards, and other services (Tolesa Agama et al., 2023). In the production approach, fee-based income is important to generate service output beyond credit activities. (Liu et al., 2024) demonstrate that fee-based income constitutes non-interest revenue derived from banking services. Although this revenue can enhance income diversification, its impact on efficiency is not always significant.

g. **H10**: Net income influence on the efficiency scores with the profit approach.

Net profit is the primary output in the profit approach to generate profits after accounting for all revenues and expenses (Horvat et al., 2023). Banks capable of generating higher net profits relative to their use of available assets, equity, and operating expenses tend to exhibit better profit efficiency. (Kweh et al., 2024) emphasize that profitability efficiency is a crucial dimension in evaluating bank efficiency because the ability to generate profit does not always equate to the ability to manage operational resources. (Blankson et al., 2022) state that net profit is not always the primary determinant of efficiency, as efficiency also depends on a bank's capability to manage inputs proportionally.

C. RESEARCH METHODS

This study uses an explanatory design and a quantitative methodology. The research subjects are conventional commercial banks listed on the IDX during 2021–2024. This study focuses on measuring banking efficiency with two approaches, namely production and profit approach, followed by panel data regression to test factors related to efficiency scores. DEA was selected because this method can evaluate the decision-making units with several inputs and outputs, the DEA method is also frequently used in contemporary banking efficiency studies, including in the research (Ullah et al., 2023) that measured bank efficiency using DEA and analyzed its determinants through a regression model. The research sample was determined using purposive sampling, which involves selecting samples based on specific criteria: banks listed on the IDX during the observation period, having published complete annual reports, possessing the necessary data for all DEA input and output variables, and excluding Islamic banks or non-bank financial institutions. Based on these criteria, 32 banking companies were chosen as the study sample, yielding 128 panel observations during the span of the four-year observation period.

The inputs in this study are equity, assets, and operating expenses. Assets are measured by the total net asset. The distinction of total assets and total liabilities represents a bank's total equity, which is used to calculate equity. Operating expenses are measured by the total operating costs incurred by the bank over one year, including labor costs, general and administrative expenses, depreciation expenses, and other operating expenses. The selection of these inputs is operational infrastructure capacity, equity reflects capital capacity, while operating expenses reflect the costs the bank incurs in generating output. The study (Istaiteyeh et al., 2024) also indicates that research on bank efficiency commonly employs internal financial variables and the DEA approach to measure relative efficiency, followed by an analysis of its determinants using second-stage regression. Output variables are distinguished based on the specific DEA approach employed. In the profit approach, the output used is net profit, which is the current year's profit after deducting all expenses and taxes. This approach views the bank as a business entity that uses assets, equity, and operating expenses to generate profits. In the production approach, the outputs used are loans granted, third-party funds, and fee-based income. Loans granted reflect the bank's primary function in channeling funds to the public; third-party funds reflect the bank's capability to manage and deploy public funds through checking accounts, savings, and

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deposits; while fee-based income reflects the bank's ability to make non-interest service revenue. The distinction between outputs based on the production and profit approaches is made because a bank's efficiency is not solely related to profitability but also to its ability to perform intermediary functions and provide banking services (Nugraha et al., 2023) also distinguishes between the production and profit approaches in measuring bank efficiency, whereas (Yewisa & Satrianto, 2025) use assets, equity, operating expenses, and net income when evaluating cconventional commercial banks' effectiveness using asset categorisation.

After the efficiency scores were obtained, the study proceeded with panel data regression. The panel model allows the study to capture differences in characteristics across banks as well as changes over time. The regression models are divided into two models. The first model uses the production approach efficiency score as the dependent variable, while the second model uses the profit approach efficiency score as the dependent variable. This model is used to determine whether the input and output variables that form the DEA model have an empirical relationship with the resulting efficiency scores is formulated as follows:

$$EFFPROFIT_{it} = \alpha + \beta_1 AT_{it} + \beta_2 EQ_{it} + \beta_3 BO_{it} + \beta_4 LB_{it} + \varepsilon_{it}$$
$$EFFPROD_{it} = \alpha + \beta_1 AT_{it} + \beta_2 EQ_{it} + \beta_3 BO_{it} + \beta_4 KRD_{it} + \beta_5 DPK_{it} + \beta_6 FBI_{it} + \varepsilon_{it}$$

Notes:
EFFPROFIT : profit approach efficiency score
EFFPROD : production approach efficiency score
AT : asset
EQ : equity
BO : operating expense
LB : net income
KRD : loan
DPK : third-party fund
FBI : fee based income
i : bank
t : year

D. RESULTS AND DISCUSSION

Banking Efficiency

The profit approach was used to measure the banks' ability to generate net profit from inputs such as fixed assets, equity, and operating expenses. Meanwhile, the production approach was used to measure the banks' ability to generate intermediation and service outputs, namely loans granted, third-party funds, and fee-based income. A summary of the profit approach efficiency scores is presented in table, while the production approach efficiency scores in Table 4 and Table 5.

Table Efficiency Scores with Large Asset Classifications Using the Profit Approach

No	DMU	Efficiency Scores				Average
		2021	2022	2023	2024	
1	Mandiri	1.000	0.940	0.955	0.613	0.877
2	Rakyat Indonesia (BRI)	0.794	0.906	0.951	0.598	0.812
3	Central Asia (BCA)	1.000	1.000	1.000	1.000	1.000
4	Negara Indonesia (BNI)	0.867	0.957	0.992	0.451	0.817
5	Tabungan Negara (BTN)	0.977	0.993	0.924	0.530	0.856
6	CIMB Niaga	0.981	0.991	0.961	0.464	0.849
7	OCBC NISP	0.969	0.986	0.935	0.422	0.828
8	Permata	0.922	0.964	0.899	0.185	0.743
9	Danamon Indonesia	0.968	0.959	0.998	0.279	0.801
10	Pan Indonesia	0.973	0.989	0.992	0.293	0.812
11	Pembangunan Daerah Jawa Barat dan Banten (BJB)	0.967	0.983	0.850	0.737	0.884
12	Maybank Indonesia	0.972	0.992	0.889	0.323	0.794
13	Mayapada Internasional	0.116	0.081	0.066	0.015	0.070

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14	Mega	1.000	1.000	0.925	1.000	0.981
15	Sinarmas	0.330	0.703	0.198	0.083	0.329
16	China Construction	0.324	0.441	0.513	0.105	0.346
17	Nationalnobu	0.174	0.322	0.315	0.174	0.246
18	Victoria International	0.310	0.690	0.249	0.189	0.360
19	Artha Graha Internasional	0.439	0.145	0.307	0.212	0.276
20	Jago	0.377	0.082	0.295	0.215	0.242
21	Multiarta Sentosa	0.548	0.661	0.443	0.377	0.507
	Average	0.715	0.752	0.698	0.394	0.639

Source: Data Processed, 2026

Table Efficiency Scores with Medium Assets Using the Profit Approach

No	DMU	Efficiency Scores				Average
		2021	2022	2023	2024	
1	MNC Internasional	0.035	0.158	0.231	0.030	0.114
2	Mestika Dharma	0.880	0.964	0.856	1.000	0.925
3	IBK Indonesia	0.048	0.313	0.503	0.031	0.224
4	Ina Perdana	0.106	0.452	0.404	0.087	0.262
5	Capital Indonesia	0.093	0.104	0.254	0.078	0.132
6	Ganesha	0.033	0.178	0.334	0.039	0.146
7	Bumi Arta	0.165	0.176	0.194	0.161	0.174
8	Oke Indonesia	0.058	0.058	0.125	0.070	0.078
9	Pembangunan Daerah Banten	0.784	1.000	0.113	0.165	0.516
10	India Indonesia	0.355	0.093	0.235	0.356	0.260
11	Krom Bank Indonesia	0.240	0.682	1.000	0.816	0.685
	Average	0.254	0.380	0.386	0.258	0.319

Source: Data Processed, 2026

DEA results indicate that the sampled commercial banks achieve higher efficiency under the production approach (average: 0.8666) compared to the profit approach (average: 0.5328). This suggests that banks excel at generating operational outputs such as loans, third-party funds, and fee-based income but remain suboptimal in converting inputs (fixed assets, equity, and operating expenses) into net profit. Profit efficiency varies drastically, ranging from a minimum of 0.0150 to a maximum of 1.0000. By asset size, large-asset banks outperform medium-asset banks with an average score of 0.639 versus 0.319. Individually, Bank Central Asia (1.000) and Bank Mayapada (0.070) represent the highest and lowest scores in the large-asset tier, while Bank Mestika Dharma (0.925) and Bank Oke Indonesia (0.078).

Table Efficiency Scores with Large Asset Classifications Using the Production Approach

No	DMU	Efficiency Scores				Average
		2021	2022	2023	2024	
1	Mandiri	1.000	0.906	0.892	1.000	0.950
2	Rakyat Indonesia (BRI)	0.106	0.991	0.982	1.000	0.770
3	Central Asia (BCA)	0.998	1.000	1.000	1.000	0.999
4	Negara Indonesia (BNI)	0.993	1.000	0.978	1.000	0.993
5	Tabungan Negara (BTN)	0.964	1.000	1.000	1.000	0.991
6	CIMB Niaga	0.952	0.999	0.986	0.981	0.980
7	OCBC NISP	0.927	0.999	0.998	0.983	0.977
8	Permata	0.932	0.981	0.988	0.971	0.968
9	Danamon Indonesia	0.914	1.000	1.000	1.000	0.979
10	Pan Indonesia	0.907	0.997	0.996	0.993	0.973
11	Pembangunan Daerah Jawa Barat dan Banten (BJB)	0.897	0.997	0.998	1.000	0.973
12	Maybank Indonesia	0.891	0.998	0.997	0.996	0.971
13	Mayapada Internasional	0.874	1.000	1.000	0.988	0.966
14	Mega	0.875	0.996	0.998	0.957	0.957
15	Sinarmas	0.748	1.000	1.000	0.980	0.932
16	China Construction	0.556	0.941	0.945	1.000	0.861
17	Nationalnobu	0.510	0.933	0.934	1.000	0.844
18	Victoria International	0.540	0.968	0.968	0.965	0.860
19	Artha Graha Internasional	0.578	0.976	0.981	1.000	0.884
20	Jago	0.281	0.937	0.919	1.000	0.784
21	Multiarta Sentosa	0.568	0.973	1.000	0.995	0.884
	Average	0.762	0.981	0.979	0.991	0.928

Source: Data Processed, 2026

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Table Efficiency Scores with Medium Assets Using the Production Approach

No	DMU	Efficiency Scores				Average
		2021	2022	2023	2024	
1	MNC Internasional	1.000	0.941	0.918	0.957	0.954
2	Mestika Dharma	0.419	0.914	0.886	0.951	0.793
3	IBK Indonesia	0.302	0.871	0.895	0.945	0.753
4	Ina Perdana	0.447	0.950	0.957	0.993	0.837
5	Capital Indonesia	0.555	1.000	1.000	1.000	0.889
6	Ganesha	0.796	0.767	0.801	0.827	0.798
7	Bumi Arta	0.287	0.731	0.732	0.755	0.626
8	Oke Indonesia	0.287	1.000	0.985	0.973	0.811
9	Pembangunan Daerah Banten	0.230	0.770	0.741	0.780	0.630
10	India Indonesia	0.116	0.597	0.776	1.000	0.622
11	Krom Bank Indonesia	0.063	0.313	0.313	1.000	0.422
	Average	0.409	0.805	0.819	0.926	0.740

Source: Data Processed, 2026

Banks demonstrate superior technical capacity under the production approach (mean: 0.8667, median: 0.9710), proving highly capable of utilizing assets and equity to drive operational outputs. Large-asset institutions performed closest to the frontier (mean: 0.928), with their average efficiency rising from 0.762 in 2021 to 0.991 in 2024, spearheaded by Bank Central Asia (0.999). Medium-asset banks recorded a lower average of 0.740, though they experienced a notable upward trajectory from 2021 (0.409) to 2024 (0.926), ranging from Bank MNC Internasional (0.954) to PT Krom Bank Indonesia (0.422). Overall, the study underscores a clear imbalance: commercial banks are remarkably efficient at extending credit and gathering third-party funds, but fail to translate this intermediation success into bottom-line profitability.

Descriptive Statistics

Tabel Descriptive Statistical Results

	Asset	Equity	Operating Expense	Loan	Third Party Fund	Fee Based Income	Net profit	Profit Scores	Production Scores
Mean	2.72E+08	42938231	11679693	1.76E+08	2.00E+08	4794649.	5910129.	0.532803	0.866661
Median	30126393	7285008.	1662572.	16313869	23357000	357585.0	239287.0	0.443000	0.971000
Maximum	2.43E+09	3.23E+08	1.16E+08	1.62E+09	1.45E+09	53948329	60425048	1.000000	1.000000
Minimum	2477550.	1641776.	147256.0	821727.0	233307.0	1273.000	10866.00	0.015000	0.063000
Std. Dev.	5.17E+08	79708905	21183486	3.35E+08	3.65E+08	10879005	14049498	0.366068	0.224195
Skewness	2.582940	2.418954	2.869353	2.522532	2.258059	2.769984	2.809815	0.092041	-2.063139
Kurtosis	8.797027	7.614027	11.36208	8.621461	6.787748	9.859495	9.704437	1.351487	6.312210
Sum	3.45E+10	5.45E+09	1.48E+09	2.23E+10	2.55E+10	6.09E+08	7.51E+08	67.66600	110.0660
Sum Sq. Dev.	3.36E+19	8.01E+17	5.65E+16	1.41E+19	1.68E+19	1.49E+16	2.49E+16	16.88477	6.333184
Observations	128	128	128	128	128	128	128	128	128

Source: Data Processed, 2026

The standard deviation values for assets 5.17E+08, loans 3.35E+08, and third-party funds 3.65E+08 indicate high variation in size and operational capacity within the sample. This suggests that the banks in the sample exhibit heterogeneous characteristics, particularly regarding assets, capital, loans, deposit mobilization, and revenue. The skewness values for the variables of assets, equity, operating expenses, loans, DPK, fee-based income, and profit are all positive. This indicates that the distribution of financial variables tends to be right-skewed, meaning there is a small portion of banks with very large financial values compared to other banks. This condition reflects the existence of significant differences in business scale among conventional commercial banks in the sample. The kurtosis values for several variables are also relatively high, particularly for operating expenses at 11.36208, fee-based income at 9.859495, profit at 9.704437, loans at 8.621461, and assets at 8.797027. These values indicate that the data exhibits a sharp distribution and that there are extreme variations among some banks. Thus, the descriptive statistics reveal that the banks'

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financial data is not evenly distributed but is dominated by a few large-scale banks. Regarding efficiency scores, the skewness value of the profit approach at 0.092041 indicates a relatively symmetrical distribution. Meanwhile, the skewness of the production approach at -2.063139 indicates a left-skewed distribution. This means that most banks have high production efficiency scores, while only a small number of banks have low production efficiency scores.

Model of Panel Data regression

Table Chow Test Results

Profit Approach			Production Approach		
Effects Test	Statistic	Prob.	Effects Test	Statistic	Prob.
Cross-section F	8.2919	0.0000	Cross-section F	1.5474	0.0483
Cross-section Chi-square	170.6792	0.0000	Cross-section Chi-square	54.7546	0.0053

Source: Data Processed, 2026

Table Husman Test Results

Profit Approach			Production Approach		
Test Summary	Chi-Sq. Stat	Prob.	Test Summary	Chi-Sq. Stat	Prob.
Cross-section random	22.1565	0.0002	Cross-section random	9.5411	0.1454

Source: Data Processed, 2026

Table Lagrange Multiplier Test Results

	Production Approach		
	Cross-section	**Time**	**Both**
Breusch-Pagan	0.3245 (0.5689)	185.1510 (0.0000)	185.4756 (0.0000)

Source: Data Processed, 2026

The panel data regression model selection yields different optimal models for each approach. For the profit approach, the Fixed Effects Model (FEM) is preferred, as both the Chow and Hausman tests yield probability values well below the 0.05 threshold (0.0000 and 0.0002, respectively). Conversely, the production approach is best suited by the Common Effects Model (CEM). Although its Chow test initially favors FEM ($p < 0.05$), the subsequent Hausman test indicates that the Random Effects Model (REM) is more appropriate ($p = 0.1454 > 0.05$). Finally, the Lagrange Multiplier (Breusch-Pagan) test results in a value of 0.5689 (> 0.05), confirming that CEM outperforms REM.

Test of Classical Assumptions
Multicollinearity Test

In accordance with the findings derived from the multicollinearity test, all variables in the profit approach and production approach models have VIF values < 10, so both models are deemed free from multicollinearity issues. In the profit approach model, the VIF values are 2.4418 for assets, 6.8218 for equity, 3.1086 for operating expenses, and 4.4199 for profit. All of these values, there is no significant correlation among the independent variables. In the production approach, the VIF values are 6.8041 for assets, 3.1154 for equity, 6.2462

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for operating expenses, 6.2750 for loans, 7.2767 for third-party funds, and 1.9581 for FBI. Although some variables have relatively high VIF values, all remain below 10.

Table Multicollinearity Test Results

Profit Approach		Production Approach	
Variable	**VIF**	**Variable**	**VIF**
Asset	2.4418	Asset	6.8041
Equity	6.8218	Equity	3.1154
Operating Expense	3.1086	Operating Expense	6.2462
Net Income	4.4199	Loan	6.2750
		Third-Party Fund	7.2767
		FBI	1.9581

Source: Data Processed, 2026

Heteroscedasticity Test

In accordance with the findings derived from the heteroscedasticity test with the Glejser test, all variables in the profit approach and production approach models have probability values above 0.05. Thus, both models are deemed to have no heteroscedasticity issues. In the profit approach model, the probability values for assets are 0.4523, equity 0.6352, operating expenses 0.2248, and profit 0.1473. All of these values are higher than 0.05, therefore the independent variables do not have a significant effect on the absolute residual values. In the production approach model, the p-values are 0.9629 for assets, 0.1679 for equity, 0.1140 for operating expenses, 0.3558 for loans, 0.3327 for DPK, and 0.1913 for FBI. Thus, the profit approach and production approach models satisfy the assumption of homoscedasticity, making them suitable for proceeding to the panel data regression estimation stage.

Table Heteroscedasticity Test Results

Profit Approach		Production Approach	
Variable	**Prob.**	**Variable**	**Prob.**
Asset	0.4523	Asset	0.9629
Equity	0.6352	Equity	0.1679
Operating Expense	0.2248	Operating Expense	0.1140
Net Income	0.1473	Loan	0.3558
		Third-Party Fund	0.3327
		FBI	0.1913

Source: Data Processed, 2026

Autocorrelation Test

In accordance with the findings derived from the autocorrelation test with the Durbin-Watson statistic, if the DW is between dU and 4 − dU, the model is assumed to be autocorrelation-free. In the profit approach model, the DW Stat value is 2.191321, while the dU value is 1.7763 and 4 − dU is 2.2237. Since the DW value falls between 1.7763 < 2.191321 < 2.2237, the profit approach model does not exhibit autocorrelation. In the production approach model, the DW Stat value is 2.122869, while the dU value is 1.8105 and 4 − dU is 2.1895. Since the DW value falls within the range 1.8105 < 2.122869 < 2.1895, the production approach model also does not exhibit autocorrelation. Thus, both the profit approach and production approach models satisfy the assumption of no autocorrelation and are suitable for panel data regression estimation.

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Table Autocorrelation Test Results

Profit Approach			Production Approach		
DW Stat	*Du*	4-*du*	*DW* Stat	*Du*	4-*du*
2.191321	1.7763	2.2237	2.122869	1.8105	2.1895

Source: Data Processed, 2026

Panel Data regression and Hypothesis Test

Table Regression Results

Profit Approach			Production Approach		
Variable	**Coefficient**	**Prob.**	**Variable**	**Coefficient**	**Prob.**
C	0.954107	0.0000	C	0.792338	0.0000
Asset	-2.78E-11	0.8700	Asset	-2.44E-12	0.9870
Equity	-6.71E-09	0.2264	Equity	1.12E-09	0.5798
Operating Expense	-2.69E-08	0.0024	Operating Expense	1.03E-08	0.0354
Net Income	3.07E-08	0.0049	Loan	8.74E-11	0.8621
			Third-Party Fund	5.92E-10	0.2261
			FBI	-4.74E-08	0.0007

Regression equation:
PROFIT = 0.954107 - 2.78e-11*AT* - 6.71e-09*EQ* - 2.69e-08*BO* + 3.07e-08*LB*

PRODUCTION = 0.792338 - 2.44e-12*AT* + 1.12e-09*EQ* + 1.03e-08*BO* + 8.74e-11*KRD* + 5.92e-10*DPK* - 4.74e-08*FBI*

The profit approach equation shows that the constant value of 0.954107 represents the baseline value of the profit efficiency score when the variables of fixed assets, equity, operating expenses, and net income are held constant. The fixed assets coefficient of -2.78E-11 indicates that every increase in fixed assets is followed by a change in the profit efficiency score of -2.78E-11. The equity coefficient of -6.71E-09 indicates that every increase in equity is followed by a change in the profit efficiency score of -6.71E-09. The operating expense coefficient of -2.69E-08 indicates that every increase in operating expenses is followed by a change in the profit efficiency score of -2.69E-08. Meanwhile, the net income coefficient of 3.07E-08 indicates that every increase in net income is followed by a change in the profit efficiency score of 3.07E-08. Meanwhile, the production approach is 0.792338 that baseline value of the production efficiency score when the variables of fixed assets, equity, operating expenses, credit, DPK, and fee-based income are held constant. The fixed assets coefficient of -2.44E-12 indicates that every increase in fixed assets is followed by a change in the production efficiency score of -2.44E-12. The equity coefficient of 1.12E-09 indicates that every increase in equity is followed by a change in the production efficiency score of 1.12E-09. The operating expense coefficient of 1.03E-08 indicates that every increase in operating expenses is followed by a change in the production efficiency score of 1.03E-08. The credit coefficient of 8.74E-11 indicates that every increase in loans granted is followed by a change in the production efficiency score of 8.74E-11. The DPK coefficient of 5.92E-10 indicates that every increase in third-party funds is followed by a change in the production efficiency score of 5.92E-10. The FBI coefficient of -4.74E-08 indicates that every increase in fee-based income is followed by a change in the production efficiency score of -4.74E-08.

The profit approach model yields an R-squared of 0.7917 (Adjusted R-squared = 0.7124), indicating that 79.17% of the variance in profit efficiency is accounted

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for by the included independent variables. Meanwhile, the production approach with an R-squared of 0.6486 and an Adjusted R-squared of 0.6060. Furthermore, both models are statistically valid, as their F-statistics probability values (0.0000 for profit and 0.0032 for production) fall well below the 0.05 significance level, confirming that the independent variables simultaneously exert a significant influence on the respective efficiency scores. Empirical results indicate that the asset variable has no significant impact on efficiency scores in either framework, leading to the rejection of H_1 and H_2. Specifically, the profit approach yields an asset coefficient of -2.78E-11 ($p = 0.8700$), while the production approach shows a coefficient of -2.44E-12 ($p = 0.9870$). These findings demonstrate that a larger asset scale does not inherently guarantee superior profit generation or operational output. Theoretically, while assets reflect resource capacity, efficiency is determined by a bank's ability to optimally transform inputs into outputs rather than its sheer size. This outcome corroborates which suggests that extensive asset bases can introduce operational complexities and cost management challenges that hinder efficiency gains.

In the profit approach, equity has a coefficient of -6.71E-09 with a probability of 0.2264, while in the production approach, the coefficient is 1.12E-09 with a probability of 0.5798. Thus, H3 and H4 are rejected. These findings suggest that a substantial financial base does not always make a bank more efficient if it is not used productively to generate profits, loans, deposits, or service revenue. In intermediation and efficiency theory, a bank's capital serves as a supporting capacity; however, it can only enhance efficiency when combined with effective funding strategies, cost control, and the creation of optimal output. This finding supports the view that internal bank factors do not always have the same influence on efficiency, as efficiency is influenced by a combination of the ability to manage resources, governance, risk management, and operational structure.

The efficiency score is significantly impacted by the operational expenditure variable in both approaches, but in opposite directions. In the profit approach, operating expenses have a coefficient of -2.69E-08 with a probability of 0.0024, thus H6 is accepted. The negative direction implies that an increase in operating expenses tends to reduce profit efficiency. This means that the greater the operating expenses that are not offset by an increase in net profit. This result is consistent with the concept of operational efficiency, which states that costs are inputs that must be controlled to prevent them from reducing a bank's ability to generate financial output. The study by (Gardijan Kedžo & Tuškan Sjauš, 2021) also classifies cost categories as inputs and revenue categories as outputs in bank DEA analysis, so bank efficiency is closely tied to the ability to optimally convert costs into revenue. In the production approach, operating expenses have a coefficient of 1.03E-08 with a probability of 0.0354, so H5 is accepted. The positive direction indicates that an increase in operating expenses can be followed by an increase in production efficiency if these costs are used to support intermediation activities and services, such as credit disbursement, deposit mobilization, and the enhancement of fee-based income. Thus, operating expenses are not always a source of inefficiency. In the production approach, operating costs can serve as productive inputs if used to strengthen services, operational networks, technology, and fund mobilization and disbursement activities. This finding highlights the differing characteristics between the profit approach and the production approach: costs that reduce profits can still be productive in generating the bank's operational output.

The credit coefficient is 8.74E-11 with a probability of 0.8621, so H7 is rejected. According to intermediation theory, credit is a bank's primary output because it reflects the function of channeling funds to the public and productive sectors. However, these results show that the volume of credit does not necessarily reflect efficiency if it is not accompanied by portfolio quality, credit productivity, and the ability to generate commensurate income. Venugopal found that due to the influence of credit on efficiency varying depending on the kind of credit, the bank category, and the quality of loan portfolio management. The DPK coefficient is 5.92E-10 with a probability of 0.2261, so H8 is rejected. These findings imply that the amount of funds mobilized from the public does not necessarily improve a bank's production efficiency. According to intermediation theory, DPK is the primary source of funds

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for banks; however, these funds can only generate efficiency if they are managed into productive assets, high-quality loans, interest income, or service income. Thus, these findings suggest that fundraising is not enough to increase productivity unless accompanied by a productive fund allocation strategy. This finding is consistent with the DEA approach, which assesses efficiency not based on the magnitude of inputs or outputs separately.

The FBI coefficient is -4.74E-08 with a probability of 0.0007, so H9 is accepted. The negative direction indicates that an increase in fee-based income in this model is actually followed by a decrease in the production efficiency score. This finding may occur if service revenue is not yet generated efficiently because it requires relatively high costs for technology, digital services, promotion, or supporting infrastructure. Theoretically, fee-based income reflects the diversification of non-interest income, but the findings of this study show that income diversification does not always directly improve production efficiency. DEA model did not result in significant differences in the mean and median efficiency scores compared to the traditional DEA model, indicating that non-interest income is not always the primary driver of bank efficiency. The net profit coefficient is 3.07E-08 with a probability of 0.0049, so H10 is accepted. This finding aligns with the profit approach concept, as net profit is the primary output used to assess a bank's ability to convert fixed assets, equity, and operating expenses into profit. Thus, banks capable of generating a net profit higher than the inputs used will have better profit efficiency. This finding also reinforces the argument that the profit approach is important because a bank's efficiency is measured not only by its ability to generate intermediation outputs but also by its ability to generate final profits.

Overall, in the profit approach, the significant variables are operating expenses and net income, while assets and equity are not significant. In the production approach, the significant variables are operating expenses and fee-based income, while assets, equity, loans, and customer deposits are not significant. These findings suggest that the efficiency of conventional commercial banks is not solely determined by the magnitude of financial resources, such as assets and equity, but is more determined by how banks manage costs and generate outputs relevant to the efficiency approach used. These results also underscore the importance of using both DEA approaches. The production approach describes a bank's efficiency in generating intermediation and service outputs, while the profit approach describes a bank's efficiency in generating net profit. The difference in results between the two approaches indicates that a bank that is efficient in production activities is not necessarily efficient in generating profit.

E. CONCLUSION AND SUGGESTIONS

Banking production and intermediation functions have been performing relatively well, but this has not yet been fully accompanied by the ability to generate profit efficiently. In other words, banks are capable of generating operational output volume, but the process of converting inputs such as fixed assets, equity, and operating expenses into net profit remains suboptimal. This discrepancy underscores that a bank's efficiency cannot be assessed solely by its ability to generate loans or mobilize funds, but must also be evaluated based on its capacity to generate sustainable profits. Panel data regression results indicate that, under the profit approach, the variables significantly influencing the efficiency score are operating expenses and net profit. These findings indicate that a bank's profit efficiency is more determined by its ability to control operational costs and generate profits, rather than solely by the size of its assets or capital. In the production approach, the variables significantly influencing the efficiency score are operating expenses and fee-based income. Operating expenses have a positive impact on production efficiency, while fee-based income has a negative impact. Assets, equity, loans granted, and third-party funds do not have a significant impact. Operating expenses can serve as productive inputs when used to support banking intermediation and services. However, the negative impact of fee-based income suggests that service-based revenue is not yet fully generated efficiently, likely because it still requires relatively substantial costs for services, technology, digitalization, and supporting infrastructure. Overall, banks have performed well in carrying out their intermediation and

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service functions, but still face challenges in optimizing net profit. Therefore, improving banking efficiency must not only focus on increasing assets, capital, loans, and third-party funds, but also on cost control, revenue quality, asset productivity, and the efficiency of digital business models.

For bank management, in the profit approach, operational expenses have been shown to reduce profit efficiency, so banks need to strengthen cost-efficiency strategies, optimize branch networks, digitize business processes, and evaluate labor, technology, maintenance, and administrative costs. However, since operational expenses have a positive impact on the production approach, cost-cutting should not be implemented mechanically. Banks need to distinguish between unproductive costs and costs that support output creation, such as technology costs, digital services, service expansion, and improvements in the quality of intermediation. Increasing net profit must be the primary focus in improving profit efficiency. Banks need to enhance the quality of revenue, strengthen credit risk management, optimize funding cost structures, and expand more stable revenue sources. Fee-based income also needs to be managed more efficiently. Although non-interest income is important for revenue diversification does not necessarily improve production efficiency. Therefore, banks need to ensure that the service revenue generated is commensurate with the costs of technology, promotion, services, and infrastructure utilized. For future researchers, this study still has several limitations. First, the study only used several periods so do not yet reflect the entire national banking industry. Future research could expand the sample by including non-listed banks, Islamic banks, or by comparing them. Second, employed DEA using the production approach and profit approach; thus, future research could utilize alternative approaches such as the Malmquist Productivity Index, Network DEA, Super Efficiency DEA, or Slack-Based Measure DEA. Third, to obtain a more thorough grasp of the elements affecting bank efficiency, future study might include risk variables like NPL, CKPN, LDR, CAR, NIM, BOPO, and digitalization variables. Therefore, it is anticipated to help bank management develop strategies to increase efficiency, and provide information to regulators and the government in order to create banking policies that are more sustainable, competitive, sound, and productive.

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