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BANKING COMPANY EFFICIENCY IN THE DIGITAL TRANSFORMATION ERA: A MAXDEA APPLICATION BASED INTERMEDIATION APPROACH

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Abstract: *This study aims to measure the operational efficiency of the banking industry in Indonesia during the era of digital transformation using the Data Envelopment Analysis (DEA) method with an intermediation approach and uses MaxDEA Software version 8. The research sample consists of 27 banks listed on the Indonesia Stock Exchange during the 2021–2023 period. The input variables include operating costs, number of employees, and third-party funds, while the output variables consist of total loans and net income. The analysis results indicate an upward trend in average efficiency, from 0.67 in 2021 to 0.79 in 2023. However, efficiency levels across banks exhibit significant disparities. PT Allo Bank Indonesia Tbk (BBHI) is recorded as the only bank that achieved perfect efficiency for three consecutive years, while several other banks show substantial potential for improvement, particularly in terms of increasing loans and net income. The potential improvement analysis reveals that banks with low efficiency require major restructuring, whereas those with high efficiency only need minor adjustments. This study also highlights the crucial role of digital transformation in enhancing efficiency, particularly through the adoption of digital banking technologies, process automation, and the use of big data. These findings provide strategic implications for bank management and regulators in formulating sustainable efficiency improvement policies*

Keywords: *Efficiency; Data Envelopment Analysis; Intermediation; Banking Company*

Introduction

The banking industry is one of the vital sectors in a country economy. Its role as a financial intermediary institution makes banks the main drivers in supporting national development, maintaining economic stability, and increasing financial inclusion [1]. According to Sustainable Efficiency & Green Banking of 10 Major Banks in Indonesia Based on Data Envelopment Analysis [2], the main role of banking in Indonesia is to collect and distribute public funds to support national development. Its objectives include increasing the equitable distribution of development outcomes, encouraging economic growth, and maintaining national economic stability. In addition, banks are also responsible for implementing various monetary instruments and are at the forefront of supporting the national financial inclusion agenda.

In recent years, the rapid development of information technology has driven massive digital transformation in the banking sector. The digitization of banking services, such as mobile banking, digital onboarding, and the use of artificial intelligence (AI), has changed the way banks operate and compete. Digital transformation is not only about service innovation but also a benchmark for bank performance. Amid competitive pressures and increasingly high customer expectations, banks are required to run efficient business processes in order to provide quality services at lower costs [3]. This phenomena has created new challenges for banks, namely how to improve operational efficiency amid the demands of digitalization and increasingly fierce competition from both fellow financial institutions and financial technology (fintech) players. Therefore, measuring banking efficiency is an important aspect in assessing the competitiveness and sustainability of the national financial industry[4].

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[1] Mr. Vaibhav Dongare, 'Review Paper- "A STUDY ON INTROUDUCTION TO THE BANKING SECTOR IN INDIA"', *INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*, 08.05 (2024), 1–5 <https://doi.org/10.55041/IJSREM34274>.

[2] Rinti Dwijayantie Syahril Djaddang, Jmv Mulyadi, Sailendra Sailendra, Widarto Rachbini, Shanti Lysandra , Muh. Ardiansyah Syam, 'Efisiensi Berkelanjutan & Green Banking 10 Bank Besar Di Indonesia Berbasis Data Envelopment Analysis', in *Efisiensi Berkelanjutan & Green Banking 10 Bank Besar Di Indonesia Berbasis Data Envelopment Analysis*, ed. by Dwi Winarni (Jakarta: Ganesha Kreasi Semesta, 2025), p. 34.

[3] Huyen Ngo Khanh, 'Literature Review of Measuring Operational Efficiency of Commercial Banks Using DEA Model', *Journal of Economics and Business*, 7.4 (2024) <https://doi.org/10.31014/aior.1992.07.04.620>.

[4] Asrul Aminullah and others, *ANALISIS EFISIENSI BANK SWASTA DI*

Efficiency is a key indicator in assessing the extent to which an organization is able to optimize the use of its resources to produce maximum output [5]. In the context of the banking sector, efficiency not only reflects a banks ability to reduce operational costs, but also illustrates the effectiveness of managerial strategies in managing assets, utilizing technology, and providing value-added services to customers. Efficiency has become increasingly important in an era of open competition and digital transformation, where banks are required to operate in an agile, responsive, and cost-effective manner without compromising service quality[6]. The assessment of bank efficiency is also one of the evaluation tools used by regulators and investors to measure the performance and health of financial institutions.

Data Envelopment Analysis (DEA) is a widely used non-parametric method for measuring the relative efficiency of a number of decision-making units (DMUs) using various inputs and outputs [7]. Based on linear programming techniques, DEA compares each DMU to an efficiency frontier formed from the best combination of other DMUs in the sample. Units on the frontier are considered efficient, while those below it are categorized as inefficient. The main advantage of DEA is its ability to handle multiple inputs and outputs simultaneously without requiring specific assumptions about the form of the production function [8]. Therefore, DEA is a highly relevant measurement tool in various sectors such as banking, hospitals, education, and public industries, where data complexity and diversity pose challenges in performance evaluation. Thus, DEA not only provides a quantitative picture of efficiency levels but also helps identify potential improvements that can be made by each entity[9].

According to financial report data for 2023, the five banks with the largest

INDONESIA DALAM PERANNYA UNTUK MENGHASILKAN LABA.

[5] Fuad Lian, 'Analisis Efisiensi Dengan Metode Data Envelopment Analysis (DEA) Pada Lembaga Amil Zakat Muhammadiyah', *Jurnal Maneksi*, 12.2 (2023), 246–52.

[6] Ferry Adrian, 'Analysis of Bank Efficiency in Indonesia Based on Financial Ratios', *Eduvest - Journal of Universal Studies*, 5.8 (2025), 10481–99 <https://doi.org/10.59188/eduvest.v5i8.51270>.

[7] Rinti Dwijayantie and Jmv Mulyadi, 'JIAFE (Jurnal Ilmiah Akuntansi Fakultas Ekonomi) EFISIENSI PERUSAHAAN MANUFAKTUR DENGAN DATA ENVELOPMENT ANALYSIS', 8.2 (2022), 253–70 <https://doi.org/10.34204/jiafe.v>.

[8] Salah Mohammed Abdulahi and others, 'Factor Affecting Technical Efficiency of the Banking Sector: Evidence from Ethiopia', *Cogent Economics and Finance*, 11.1 (2023) <https://doi.org/10.1080/23322039.2023.2186039>.

[9] Oding Syafrudin, Hadi Satria Ganefi, and Arief Surya Lesmana, 'Determinan Efisiensi Industri Perbankan Di Indonesia

assets in Indonesia in 2023 are as follows:

Table 1 Annual Asset Growth

No	Bank Name	Total Assets (Rp) in Trillions	Annual Growth
1	Bank Mandiri (BMRI)	2,174.2	(+9.12%)
2	Bank Rakyat Indonesia (BBRI)	1,965.0	(+5.33%)
3	Bank Central Asia (BBCA)	1,408.1	(+7.10%)
4	Bank Negara Indonesia (BBNI)	1,086.7	(+5.53%)
5	Bank Tabungan Negara (BBTN)	438.7	(+9.10%)

Source : Authors own work

Based on Table 1 Bank Mandiri (BMRI) leads with Rp 2,174.2 trillion, followed by Bank Rakyat Indonesia (BBRI), Bank Central Asia (BBCA), Bank Negara Indonesia (BBNI), and Bank Tabungan Negara (BBTN). In terms of annual growth, it is interesting to note that although BBTN has much smaller assets than other banks, its annual growth reached 9.10%, almost on par with BMRI. Meanwhile, BBRI and BBNI, which have large assets, actually showed relatively lower growth. This indicates that banks with smaller assets, such as BBTN and BBCA, have the potential to be more efficient in converting assets into growth, compared to banks with large assets but relatively low output. To prove whether banks with high annual growth have reached an efficient level, researchers conducted an efficiency test using the data envelopment analysis (DEA) intermediation approach.

Table 2 Efficiency Test Results

No	Code	Efficiency Score			Average
		2021	2022	2023	
1	BBCA	1.00	0.98	1.00	0.99
2	BMRI	0.84	0.90	1.00	0.91
3	BBTN	0.78	0.91	1.00	0.90
4	BBRI	0.78	0.88	1.00	0.89
5	BBNI	0.79	0.88	0.92	0.86

Source : Authors own work

Based on Table 2, the efficiency test results using data envelopment analysis (DEA) containing the efficiency scores of five major Indonesian banking companies (BBCA, BMRI, BBTN, BBRI, and BBNI) over a three-year period (2021–2023) shows that Bank Central Asia (BBCA) has the most consistent and high

efficiency performance, with a perfect score (1.00) in 2021 and 2023, and a slight decline to 0.98 in 2022. BBCA's average score is 0.99, indicating that this bank operates very efficiently throughout most of the evaluation period. Meanwhile, Bank Mandiri (BMRI) showed an upward trend in efficiency from 0.84 (2021) to 0.90 (2022), then reached full efficiency (1.00) in 2023, with an average score of 0.91. This indicates a significant improvement in the banks operational performance from year to year. Overall, this data shows that most banks have experienced an increase in efficiency over the past three years, with the majority achieving maximum efficiency in 2023.

Research by Adrian et al. (2025) shows that the operational efficiency of state-owned commercial banks is not yet fully optimal. The results of the analysis using the DEA approach with the CRS (Constant Return to Scale) model show that only Bank BTN consistently achieved efficiency levels throughout the entire research period[10]. The second study was conducted by Kusumaningsih et al. (2023), who examined the efficiency of Indonesian government banks using DEA. The results of the study show that of the total 26 government banks in Indonesia, only 13 banks are classified as efficient with an average efficiency score above 90%[11]. The banks that fall into the efficient category include Bank Mandiri, Bank Bali, Bank Bengkulu, Bank Jambi, Bank DIY, Bank Kalbar, Bank Kalteng, Bank Jateng, Bank Kaltimtara, Bank Maluku Malut, Bank Papua, Bank Sutalgo, and Bank Sumbar. In other words, efficiency levels were only achieved by about half of all government banks analyzed. Meanwhile, the third study was conducted by Prasetya et al. (2023), who examined the efficiency of digital banks in Indonesia using Data Envelopment Analysis (DEA). The results showed that banks with perfect efficiency accounted for 37.5% of the total sample, banks with high efficiency accounted for 37.5% of the total sample, while banks with upper-middle efficiency accounted for 25% of the total sample[12].

[10] Adrian, Analysis of Bank Efficiency in Indonesia Based on Financial Ratios', *Eduvest - Journal of Universal Studies*, 5 (2025), 10481–99 <https://doi.org/10.59188/eduvest.v5i8.51270>.

[11] JMV Mulyadi and others, *ANALISIS EFISIENSI BANK PEMERINTAH INDONESIA DENGAN DATA ENVELOPMENT ANALYSIS-DEA INDONESIAN GOVERNMENT BANK EFFICIENCY ANALYSIS USING DATA ENVELOPMENT ANALYSIS-DEA*, IX.

[12] Mikhael Garda Prasetya and Gideon Setyo Budiwitjaksono, 'EFISIENSI BANK DIGITAL DI INDONESIA MENGGUNAKAN DATA ENVELOPMENT ANALYSIS (DEA)', *Journal of Management and Bussines (JOMB*, Volume 5, (2023) <doi: 10.31539/jomb.v5i1.6035>.

Based on previous studies, the efficiency level of banks in Indonesia has not yet fully reached the optimal condition. Many banking companies obtained efficiency scores below 0.9, so further testing is needed to evaluate the efficiency level. Futhermore, most studies primarily focus on measuring and ranking efficiency scores, while providing limited analysis of the underlying sources of inefficiency and lacking quantitative, operationally oriented recommendations for improvement. Empirical evidence that explicitly captures banking efficiency within the context of digital transformation particularly during the post-pandemic period of 2021–2023 is still scarce, resulting in an incomplete understanding of digitalization as a differentiating factor in efficiency performance.

This study addresses these gaps by employing a DEA intermediation approach with a Variable Returns to Scale (VRS) model to comprehensively assess banking efficiency, identify sources of inefficiency, and quantify potential improvements, thereby offering more actionable insights for bank management and regulators in enhancing sustainable efficiency. An intermediation approach was uses, where the input variables include operating costs, number of employees, and third-party funds, while the output variables used are total loans disbursed and net income. The research questions raised in this study include: how are the efficiency rankings of banking companies listed on the Indonesia Stock Exchange, what are the factors causing inefficiency, and what improvements can be made so that companies achieve maximum efficiency. The objectives of this study are to analyze the efficiency ratings of banks, identify the causes of inefficiency, and formulate improvement strategies (potential improvement) to achieve optimal efficiency.

Literature Review

Resource Based Theory

Resource Based Theory is a theory proposed by Barney (1991) that explains a framework in strategic management that emphasizes the importance of a company internal resources and capabilities in achieving competitive advantage [13] . Resource Based Theory focuses on resources that are valuable, scarce, difficult to imitrhamate, and irreplaceable. These resources can be financial, physical, human, or organizational, and all are

[13] Bevaola Kusumasari Bhayu Rhama, 'Assessing Resource-Based Theory in Ecotourism Management: The Case of Sebangau National Park, Indonesia', *International Social Science Journal*, 2022, 613–634.

essential to achieving sustainable competitive advantage[14].

Resource-Based Theory is also related to company efficiency, where optimal performance or efficiency can be achieved if the company has a competitive advantage that can provide added value[15]. This competitive advantage is a unique characteristic inherent to the company and difficult for competitors to imitate. To obtain this advantage, companies need to manage and optimize their resources effectively[16]. Companies that are able to manage their resources well will obtain a competitive advantage that can increase the value of the company compared to its competitors. The success of a company's performance in this case can be seen from its ability to use resources optimally and to incur costs in a more economical and efficient manner.

Efficiency

Efficiency in organizational management refers to the ratio between input and output, with an emphasis on using as few resources as possible to achieve the desired results[17]. Being efficient means investing as few resources as possible to achieve the desired results. Conversely, being effective means achieving the desired results by using the right methods or taking the right actions[18]. Efficiency in the banking sector is a crucial factor that affects the stability and competitiveness of the global financial system. Efficiency is determined by how well banks utilize their resources to minimize costs and maximize output. Various studies have examined the determinants and implications of bank efficiency in different regions and banking systems. Large banks tend to show higher levels of efficiency due to economies of scale. In Ethiopia, bank size has a positive effect on efficiency, as do the number of branches and credit risk, while liquidity risk and fixed assets have a

[14] Jaap Paauwe, *Resource Based Theory*, *Elgar Online* (Elgar Online, 2024) <https://doi.org/10.4337/9781035308767.ch29>.

[15] Bhayu Rhama, Bevaola Kusumasari, 'Assessing Resource-Based Theory in Ecotourism Management: The Case of Sebangau National Park, Indonesia', *International Social Science Journal*, 2022, 613–634

[16] Intania Rahma Arieka Putri and Leny Suzan, 'PENGARUH INTELLECTUAL CAPITAL TERHADAP PROFITABILITAS DAN PRODUKTIVITAS (Studi Pada Perusahaan Sektor Infrastruktur , Utilitas , Dan Transportasi Yang Terdaftar Di Bursa Efek Indonesia Periode 2014-2017) THE INFLUENCE OF INTELLECTUAL CAPITAL ON PROFITAB', 6.2 (2019), 3241–48.

[17] Syafrudin, Satria Ganefi, and Surya Lesmana. Determinasi Efisiensi Industri Perbankan d Indonesia. Jurnal Riset Ekonomi dan Bisnis. 113-125.2024.

[18] B. W. Najar, 'Efficiency and/or Effectiveness in Managing Organizations', *Journal of Education and Culture*, 2020, 131 <https://doi.org/10.22158/JECS.V4N2P131 >.

negative impact [19]. A similar situation occurs in Indonesia, where banks with capital of more than 70 trillion rupiah show superior efficiency. Efficiency measurements in the banking sector have been carried out using various approaches, both parametric and non-parametric [20]. Parametric approaches include the Stochastic Frontier Approach (SFA) and the Distribution Free Approach (DFA). Meanwhile, this study adopts a non-parametric approach, namely Data Envelopment Analysis (DEA). The classification of efficiency levels is based on the scores and categories proposed by Dwijayantie et al (2022) [21], which divides efficiency levels into six categories, as shown in Table 3 below.

Table 3 Efficiency Score Values

Efficiency Score	Category
1.00	Perfect Efficiency (Efficient)
< 1.00 – 0.80	High Efficiency
< 0.80 – 0.60	Upper-Middle Efficiency
< 0.60 – 0.40	Medium Efficiency
< 0.40 – 0.20	Lower-Middle Efficiency
< 0.20	Low Efficiency

Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a non-parametric method used to evaluate the efficiency of decision-making units (DMUs) by comparing them to a defined efficiency frontier. This method is particularly useful in contexts involving multiple inputs and outputs, and does not require assumptions about the functional form of the production process. DEA has been widely applied in various sectors, such as healthcare, education, and finance, due to its ability to handle complex and multidimensional data and provide insights into performance improvement. DEA does not assume a specific production function, making it flexible and applicable in various contexts. This method uses linear programming to form a piecewise linear frontier that encompasses all data points, allowing for relative efficiency measurement without rigid initial assumptions. DEA assesses the

[19] Abdulahi, M. Yitayaw, Feyisa.Factor affecting technical efficiency of the banking sector: Evidence from Ethiopia. *Cogent Economics and Finance.* https://doi.org/10.1080/23322039.2023.2186039.

[20] A. S. Ganefi, H. S., Syafrudin, O., & Lesmana, 'Determinant Efficiency of the Banking Industry in Indonesia', *Jurnal Riset Ekonomi Dan Bisnis*, 2024, 113 <https://doi.org/10.26623/jreb.v17i2.8994>.

[21] Rinti Dwijayantie and Jmv Mulyadi, 'JIAFE (Jurnal Ilmiah Akuntansi Fakultas Ekonomi) EFISIENSI PERUSAHAAN MANUFAKTUR DENGAN DATA ENVELOPMENT ANALYSIS', 8.2 (2022), 253–70 <https://doi.org/10.34204/jiafe.v>..

efficiency of DMUs by comparing them to the most efficient units, which are often synthetic units formed as a linear combination of reference units. The advantages of the DEA method lie in its ability to handle various inputs and outputs and its non-parametric nature, making it a powerful tool for efficiency analysis. DEA offers a data-driven approach to decision making and benchmarking, which is very useful in promoting continuous improvement.

This data envelopment analysis will produce a company efficiency score. Efficiency values can be determined by looking at the size of the efficiency score, which ranges from 0 to 1 and can be considered perfect if the value is 1. In this study, the method used is variable return to scale (VRS) or the VRS method, also known as the technical efficiency method, which assumes that input and output variables are variable. The VRS method aims to determine the actual level of efficiency that can be achieved if banks can collect and return funds to the community effectively.

Operating Costs

Operating costs are an important component of financial management in various industrial sectors because they have a direct impact on profitability, efficiency, and strategic planning. These costs include various types of expenses related to the daily operational activities of a business, including administrative, marketing, and production costs. Understanding and managing operational costs is essential for optimizing financial performance and ensuring sustainable growth [22] . Operational costs are generally classified into several categories, such as general and administrative expenses, cost of goods sold, and other specific expenses such as marketing and research and development cost [23] . In this study, operating costs include operating interest expenses and other operating costs. This variable is used as an input because it reflects the managerial role of banks in carrying out their intermediary function, which naturally requires expenditure to support the implementation of this function.

Labor

Human resources (HR) are one of the most important elements in an

[22] Pipit Mutiara, 'Pengaruh Pendapatan Dan Biaya Operasional Terhadap Laba Bersih', *J-MAS (Jurnal Manajemen Dan Sains)*, 7.1 (2022), 244 <https://doi.org/10.33087/jmas.v7i1.396>.

[23] Abdulkadir Pehlivan, Bilal Gerekan, and Mahmut Kocan, 'The Effect of Operating Expenses on Growth and Performance: An Empirical Analysis of the Petroleum and Chemistry Industry in Turkey', *Asian Economic and Financial Review* (Asian Economic and Social Society, 2020), 1299–1308 <https://doi.org/10.18488/journal.aefr.2020.1011.1299.1308>.

organization, playing a key role in achieving organizational goals and objectives through effective workforce management. HR encompasses various essential functions, such as recruitment, training, performance management, employee relations, and career development. Each of these functions aims to maximize human potential within the organization, which in turn contributes to improving the overall performance of the organization [24] . In addition, employee relations also play an important role in creating a harmonious and productive work environment. Good management of relations between management and employees can increase loyalty, reduce conflict, and strengthen team spirit. All of these functions, when managed properly, can create an organization that is able to optimize the potential of its human resources. A skilled workforce is more likely to be productive and innovative. In this study, human resources include the number of employees. The labor variable is used as an input variable in the study of banking company efficiency using Data Envelopment Analysis (DEA) because labor plays a role as one of the main resources that influence the operational processes and performance of banks.

Third-Party Funds

Third-party funds refer to financial resources collected or provided by entities not directly involved in the main transactions or activities. Third-party funds in banking are funds collected from the public, including individuals and business entities, which are used by banks to generate income. These funds are very important for the bank's operational activities and have a significant impact on their net income [25] . Third-party funding refers to financial support provided by external entities to parties involved in litigation or arbitration, enabling them to pursue their cases without bearing the entire financial burden. This type of funding is increasingly common in international arbitration due to the high value of arbitration awards. Third-party funders play an important role as procedural, financial, and substantive stakeholders, influencing the effectiveness of arguments, settlement negotiations, and the enforceability and collection of awards or

[24] Syahrizal2 Putri Seni Hati, 'Human Resource Manajemen', 3.4 (2023), 0–7 <https://doi.org/10.24036/hrms.v4i3>.

[25] Raith, A., Rouse, P., Seiford, L.M. (2019). Benchmarking Using Data Envelopment Analysis: Application to Stores of a Post and Banking Business. In: Huber, S., Geiger, M., de Almeida, A. (eds) Multiple Criteria Decision Making and Aiding. International Series in Operations Research & Management Science, vol 274. Springer, Cham. https://doi.org/10.1007/978-3-319-99304-1_1.

settlements[26]. In this study, third-party funds refer to the total current accounts, savings accounts, and time deposits recorded in the banking financial position report. The selection of third-party funding input variables is based on the fact that most banks in Indonesia still rely on third-party funding as the main source of liquidity in banking operations.

Credit

According to Law No. 7 of 1992 concerning banking, which has been amended to Law No. 10 of 1998, credit is the provision of money or bills of exchange based on a loan agreement or agreement between a bank and another party. The borrower has an obligation to repay the debt plus interest in accordance with the agreed term. Credit data is obtained from financial position reports, and in this study, the credit referred to its credit granted to related parties and third parties, after deducting the allowance for impairment losses.

Net Income

Net profit is an important financial metric that describes a company's profits after all expenses, taxes, and costs are deducted from total revenue. Net profit is a key indicator of a companys financial health and performance, providing insight into its profitability and efficiency in managing costs relative to revenue. The concept of net profit has various aspects, involving accounting principles and methodologies that can affect its calculation and interpretation. Net income is calculated by subtracting total expenses, including operating costs, taxes, and interest, from total revenue[27]. The calculation of net profit may vary depending on the accounting practices used, such as the use of historical costs versus current costs for asset valuation, as well as the treatment of realized and unrealized gains and losses[28]. In this study, net income is obtained from the company's income statement.

Research Model

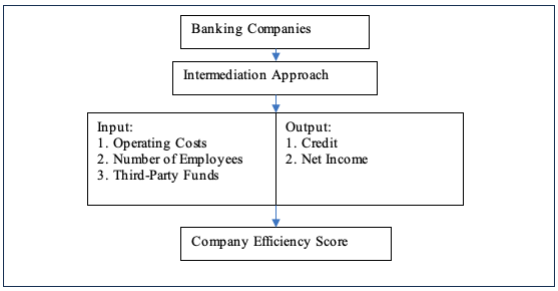
This research model can be described as follows:

Figur 1. Research Model

[26] Mulyadi and others, IX.

[27] Lujing Liu and others, 'Intellectual Capital and Financial Performance of Chinese Manufacturing SMEs: An Analysis from the Perspective of Different Industry Types', *Sustainability (Switzerland)*, 14.17 (2022) <https://doi.org/10.3390/su141710657>.

[28] Dewi Sarifah Tullah and others, 'Unveiling the Hidden Impact of Green Accounting on Corporate Success', *Riset*, 7.1 (2025), 001–014 <https://doi.org/10.37641/riset.v7i1.2588>.



Source : Authors own work

Research Methodology

This research is classified as explanatory research[29]. The type of research used is quantitative research. The population studied includes all banking companies listed on the Indonesia Stock Exchange (IDX) for the period 2021-2023. The researchers used purposive sampling techniques with annual time series data from 2021 to 2023. The total sample used in this study was 27 companies with 81 samples. The approach used in this study was the intermediation approach. The input variables used were operating costs, number of employees, and third-party funds, while the output variables used were total loans disbursed and net income. Analysis DEA are performed using MAXDEA software version 8, which enables efficiency scoring, peer benchmarking, and potential improvement analysis.

Data Envelopment Analysis (DEA) is classified as a non-parametric approach that employs linear programming techniques and assumes the absence of random error (J. M. V. Mulyadi, 2015). DEA offers several advantages over ratio and regression analyses. First, DEA is specifically designed to evaluate the efficiency of decision-making units that operate with multiple inputs and multiple outputs simultaneously. In contrast, ratio analysis measures efficiency by simply comparing output values to input values, while regression analysis constructs a model that estimates output levels as a function of various input variables.

Result and Discussion

The analysis of the results in this study includes the intermediation approach. Data Envelopment Analysis (DEA) was chosen because this method is specifically designed to assess the efficiency of decision-making units (DMUs) that have multiple inputs and outputs simultaneously, which are difficult to accommodate optimally by other analysis techniques such as ratio or regression analysis. Regression analysis measures efficiency by comparing output values to input values. A unit is said to be efficient if it is able to produce output that is greater than its estimated value. However, in cases with a large number of outputs, regression analysis becomes less satisfactory because each regression equation can only accommodate one output. If many inputs and outputs are

[29] JMV Mulyadi, Rinti Dwijayantie, 'EFISIENSI PERUSAHAAN MANUFAKTUR DENGAN DATA ENVELOPMENT ANALYSIS', *Jurnal Ilmiah Akuntansi Fakultas Ekonomi*, 8.2 (2022), 253–70 <doi: 10.34204/jiafe.v8i2.5763>.

combined at once, the information produced becomes less detailed and tends to be biased (Mulyadi, 2015). By using DEA, this study was able to evaluate the efficiency of banking companies listed in Indonesia for the period 2021–2023 using input variables in the form of operating costs, number of employees, and third-party funds, as well as output variables in the form of total credit and net income. The efficiency categories measured in this study are as follows: Perfect Efficiency, High Efficiency, Upper-Middle Efficiency, Middle Efficiency, Lower-Middle Efficiency, and Low Efficiency[30].

Intermediation Approach

Based on the test results of 27 banking companies listed on the Indonesia Stock Exchange (IDX) for the 2021-2023 period using the DEA intermediation approach method, the following efficiency scores were obtained.

Table 4. Efficiency Scores of Banking Companies Based on Ranking

No	Company Code	Efficiency Score			Avg
		2021	2022	2023	
1	BBHI	1.00	1.00	1.00	1.00
2	BBCA	1.00	0.98	1.00	0.99
3	PNBN	1.00	0.95	0.99	0.98
4	MEGA	1.00	0.97	0.93	0.96
5	AGRS	0.82	0.93	1.00	0.92
6	BMRI	0.84	0.90	1.00	0.91
7	BBTN	0.78	0.91	1.00	0.90
8	MAYA	0.74	0.95	1.00	0.90
9	BBRI	0.78	0.88	1.00	0.89
10	DNAR	0.76	0.92	0.93	0.87
11	BBNI	0.79	0.88	0.92	0.86
12	NISP	0.67	1.00	0.78	0.82
13	BDMN	0.79	0.81	0.85	0.82
14	BTPS	0.72	0.79	0.79	0.76
15	BNGA	0.68	0.74	0.82	0.75
16	ARTO	0.61	0.73	0.84	0.73
17	BTPN	0.66	0.76	0.75	0.72
18	BMAS	0.74	0.68	0.75	0.72
19	READ	0.26	1.00	0.89	0.72
20	BABP	0.57	0.54	0.57	0.56
21	BNII	0.52	0.55	0.58	0.55
22	BNLI	0.49	0.53	0.57	0.53
23	BINA	0.31	0.59	0.61	0.50
24	BNBA	0.48	0.44	0.45	0.46
25	BGTG	0.42	0.34	0.57	0.44

[30] Rina Pebriana, Insan Kamil, and Muhammad Agus Shariputra, *ANALISIS EFISIENSI SAHAM PERUSAHAAN FARMASI DI INDONESIA MENGGUNAKAN METODE DEA SOLVER DENGAN MODEL CCR DAN SBM.*

26	NOBU	0.54	0.16	0.63	0.44
27	BSIM	0.17	0.18	0.14	0.16
	Average Efficiency	0.67	0.74	0.79	0.74

Source : Authors own work

The overall average efficiency of banking companies during the 2021–2023 period shows an upward trend, from a score of 0.67 in 2021, rising to 0.74 in 2022, and reaching a score of 0.79 in 2023. This increase reflects improvements in operational performance and resource management in most banks, along with adaptation to digital transformation and cost efficiency strategies.

Based on the efficiency criteria adopted in Santoso's (2010) research, there is one bank that consistently falls into the perfect efficiency category, namely BBHI, with a score of 1.00 throughout the entire research period. Several other banks, such as BBCA, PNBN, MEGA, AGRS, BMRI, BBTN, and MAYA, are in the high efficiency category with an average score above 0.90, indicating a good ability to optimize inputs into outputs, although they have not achieved full efficiency in all years.

Meanwhile, banks such as BBRI, DNAR, BBNI, NISP, BDMN, and BTPS fall into the upper-middle efficiency category with an average score of between 0.80 and 0.89, which means there is still room for improvement, particularly in optimizing operational costs and utilizing third-party funds to increase revenue. Several other banks, including BGTG and NOBU, fall into the medium efficiency category with average scores in the range of 0.40–0.59, indicating significant inefficiencies. The bank with the lowest performance is BSIM, which is in the low efficiency category with an average score of only 0.16, indicating problems in converting inputs into outputs that need to be addressed immediately.

From the perspective of Resource-Based Theory (RBT), banks that consistently achieve high efficiency such as BBHI and BBCA can be interpreted as possessing valuable and firm-specific resources, particularly digital capabilities, data analytics infrastructure, and process automation systems. These resources enable banks to reduce operational costs, enhance credit distribution efficiency, and generate higher net income without proportionally increasing labor inputs. Conversely, banks with lower efficiency scores appear unable to optimally leverage their resources, indicating weaknesses in capability development rather than resource availability alone. This finding supports Barney's (1991) argument that competitive advantage stems not from resource ownership, but from the ability to deploy resources effectively.

The potential improvement analysis further reveals that inefficient banks

require substantial increases in credit distribution and net income, alongside reductions in operating costs and labor inputs. This suggests that inefficiency primarily arises from ineffective intermediation and low productivity, rather than insufficient funding sources. In the context of digital transformation, these results imply that banks lagging in efficiency may not yet have fully integrated digital technologies into core business processes, such as credit assessment, risk management, and customer acquisition. Digital banking adoption thus acts as a key efficiency differentiator, reinforcing its role as a strategic resource under the RBT framework.

When compared with previous studies, the findings of this study are consistent with Adrian et al. (2025) and Kusumaningsih et al. (2023), who reported that only a portion of Indonesian banks operate at optimal efficiency levels. However, this study extends prior research by explicitly incorporating potential improvement analysis, thereby quantifying the magnitude of input adjustments and output enhancements required to achieve efficiency. In contrast to Prasetya et al. (2023), who focused primarily on digital banks, this study provides a more comprehensive view by including conventional banks and demonstrating that digital transformation benefits are not limited to fully digital institutions but also apply to incumbent banks that successfully develop digital capabilities.

Overall, the findings confirm that digital transformation functions as a strategic resource that enhances banking efficiency when effectively aligned with organizational capabilities. In line with Resource-Based Theory, banks that are able to internalize digital technologies into their operational routines achieve superior efficiency and sustainable competitive advantage, while those that fail to do so remain trapped in persistent inefficiency despite having access to similar financial resources.

Table 5. Potential Improvements for Companies with High Efficiency Levels (<1.00 - 0.80)

Year	DMU	Score	Potential Improvement				
			Operating Costs	Labor	DPK	Credit	Net Income
2021	BMRI	0.84	8	16	0	-19	-62%
	AGRS	0.82	0	14	0	-22	-22
2022	BBCA	0.98	0	2	0	-421%	-2
	MEGA	0.97	0	5	0	-3	-3
	MAYA	0.95	0	0	3	-5	-146%
	PNBN	0.95	0	4	0	-6	-6
	AGRS	0.93	0	0	0	-8	-8
	DNAR	0.92	9	0	0	-8	-2207%
	BBTN	0.91	0	0	0	-10	-52
	BMRI	0.90	3	4	0	-12	-28
	BBRI	0.88	1	0	0	-16	-13
	BBNI	0.88	0	19	4	-14	-16%
	BDMN	0.81	36%	68%	0	-24	-33%
2023	PNBN	0.99	0	0	0	-1	-1
	MEGA	0.93	0	25	0	-8	-8
	DNAR	0.93	25	0	0	-8	-1068%
	BBNI	0.92	0	19	7	-8	-17%
	READ	0.89	57	0	31	-13%	-80%
	BDMN	0.85	38	66	0	-18	-41%
	ARTO	0.84	47	0	0	-19	-715%
	BNGA	0.82	0	13	0	-22	-22
Total Average		90%	11	12	2	-32%	-217

Source : Authors own work

Table 5 shows potential improvements for banking companies with high efficiency levels (< 1.00 – 0.80) throughout the research period, but they have not yet reached maximum efficiency. Based on the DEA analysis

results, the average recommended improvements include: increasing third-party fund optimization by 2%, increasing the amount of credit disbursed by 32%, increasing net income by 217%, and reducing average operating costs by 11% and labor efficiency by 12%. For example, BBCA had an efficiency score of 0.98 in 2022, indicating that although its performance was nearly optimal, there was still room for improvement. This bank was advised to increase credit distribution, raise net income by 2%, and improve labor efficiency by 2% in order to achieve perfect efficiency. Another example is BMRI, which in 2021 with an efficiency score of 0.84 still needs to increase credit distribution by 19%, net income by 62%, and reduce operating costs by 8%. Meanwhile, PNBN in 2022 has an efficiency score of 0.95 and is recommended to increase credit distribution by 6%, increase net income by 6%, and reduce labor costs by 4%.

From these results, it can be concluded that most banks in the high efficiency category already manage their resources well, but still need to make minor improvements to key variables, especially the optimization of third-party funds, credit enhancement, and operational cost management, in order to achieve a perfect efficiency score consistently throughout the research period.

Table 6. Potential Improvement for Companies with Upper-Middle Efficiency Levels (< 0.80 – 0.60)

Year	DMU	Score	Potential Improvement				
			Operating Costs	Labor	DPK	Credit	Net Income
2021	BDMN	0.79	45	68	0	-26	-169%
	BBNI	0.79	0	23	7	-27	-27
	BBTN	0.78	0	6	0	-28	-45
	BBRI	0.78	39	60	0	-28	-49%
	DNAR	0.76	0	0	0	-32	-1205%
	MAYA	0.74	0	0	0	-35%	-436
	BMAS	0.74	0	18	0	-35	-312%
	BTPS	0.72	0	0	0	-39	-145%
	BNGA	0.68	0	7	0	-48	-48
	NISP	0.67	0	0	0	-49	-23163%
	BTPN	0.66	0	57	0	-51	-51
	ARTO	0.61	34	0	0	-63	-166%
2022	BTPS	0.79	2	0	0	-27	-140
	BTPN	0.76	0	64	0	-32	-32
	BNGA	0.74	0	6	0	-35	-35
	ARTO	0.73	45	0	0	-36	-2813%
	BMAS	0.68	0	4	0	-48%	-166%
2023	BTPS	0.79	2	0	0	-27	-257%
	NISP	0.78	0	0	0	-28	-24207%
	BMAS	0.75	0	0	0	-33%	-268%
	BTPN	0.75	0	62	0	-33	-36%
	NOBU	0.63	0	0	0	-59%	-115%
	BINA	0.61	0%	0	0	-65%	-65%
Total Average		73%	7	16	0	-38	-2346

Source : Authors own work

Furthermore, Table 6 shows potential improvements for banking companies in the upper-middle efficiency category (< 0.80 – 0.60), but which have not yet reached maximum efficiency during the research period. On average, the recommended improvements include a 73% reduction in operating costs, a 7% increase in labor efficiency, a 16% optimization of third-party funds (DPK), a 38% increase in credit distribution, and a significant 2346% increase in net income. The very large increase in net income indicates the potential for high profitability if resources are managed optimally.

In 2021, a notable example is BDMN with an efficiency score of 0.79, which is recommended to reduce operating costs by 45%, reduce the number of employees by 68%, and increase credit by 26%. BBRI, with a score of 0.78, was

also advised to reduce operating costs by 39% and increase credit by 28%, in addition to a 49% increase in net income. Meanwhile, MAYA and BMAS required significant reductions in operating costs and increases in credit and net income. In 2022, ARTO, with a score of 0.73, needs to reduce operating costs by 45% and optimize its workforce by 64%. Meanwhile, BRGA and BTPS also show a need for improvement in terms of credit distribution and net income. In 2023, NOBU, with an efficiency score of 0.63, has the greatest potential for improvement with recommendations to increase credit by 56% and net income by up to 529%, as well as reduce labor by 40%. BINA even has the potential to increase credit by up to 65% and net income by more than 656%, indicating a large imbalance between the inputs used and the outputs produced.

Table 7. Potential Improvement of Companies with Medium Efficiency Levels (< 0.60 – 0.40)

Year	DMU		Potential Improvement				
		Score	Operating Costs	Labor	DPK	Credit	Net Income
2021	BABP	0.57	0	0	0	-75	-1909%
	NOBU	0.54	0	16	0	-87	-377%
	BNII	0.52	0	0	0	-92	-92
	BNLI	0.49	0	0	0	-103%	-305%
	BNBA	0.48	0	33	0	-106%	-470%
	BGTG	0.42	0	0	0%	-138%	-1847%
2022	BINA	0.59	0	0	0	-68	-68
	BNII	0.55	0	0	0	-81	-127%
	BABP	0.54	0	0	0	-86	-447%
	BNLI	0.53	0	0	0	-88%	-130%
	BNBA	0.44	0	36	0	-127%	-409%
2023	BNII	0.58	0	0	0	-72	-77%
	BABP	0.57	0	0	0	-75	-291%
	BGTG	0.57	0	0	0	-76%	-80
	BNLI	0.57	0	0	0	-77%	-121%
	BNBA	0.45	0	25	0	-120%	-345%
Total Average		0.53	0	7	0	-92	-443

Source : Authors own work

Table 7 shows the potential improvement for banking companies in the medium efficiency category (< 0.60 – 0.40), with an average efficiency score of only 0.53 during the 2021–2023 period. Overall, the recommended improvements include labor efficiency of 7%, optimization of third-party funds (DPK) of 0% on average (indicating that most banks in this category have not maximized their fund intermediation function), a significant increase in credit distribution of 92%, and a very high increase in net income of 443%. The magnitude of the potential increase in credit and net income indicates a significant imbalance between the inputs used and the outputs produced.

In 2021, banks such as BGTG have enormous potential for improvement with a 138% increase in credit and a 184% increase in net income. In 2022, BNBA recorded the highest credit increase requirement of 127% with a potential net income increase of 409%. In 2023, similar conditions still exist, with BNLI and BINA also showing high potential for credit growth, indicating that there is still considerable room for improvement in utilizing managed funds to generate optimal output.

Table 8. Potential Improvement with Medium-Low Efficiency Levels (< 0.40 – 0.20)

Year	DMU		Potential Improvement				
		Score	Operating Costs	Labor	DPK	Credit	Net Income
2021	BINA	0.31	0	0	0	-220%	-592%
	READ	0.26	52	0	50	-281%	-422%
2022	BGTG	0.34	75	0	0	-193%	-596%
Total Average		0.31	42	0	17	-231%	-536

Source : Authors own work

Table 8 shows the potential improvement for banking companies in the lower-middle efficiency category (< 0.40 – 0.20), with an average efficiency score of only 0.31 during the 2021–2023 period. Overall, the recommended improvements include reducing operating costs by 42%, optimizing third-party funds by 17%, and increasing credit distribution by 231%. For example, in 2022, BGTG is expected to achieve 75% efficiency in operational costs, a 193% increase in credit, and a 596% increase in net income to achieve maximum efficiency scores.

Table 9. Potential Improvement with Low Efficiency Level (< 0.20)

Year	DMU		Potential Improvement				
		Score	Operating Costs	Labor	DPK	Credit	Net Income
2021	BINA	0.31	0	0	0	-220%	-592%
	READ	0.26	52	0	50	-281%	-422%
2022	BGTG	0.34	75	0	0	-193%	-596%
Total Average		0.31	42	0	17	-231%	-536

Source : Authors own work

Table 9 shows potential improvements for banking companies in the low efficiency category (< 0.20), with an average efficiency score of only 0.16 during the 2021–2023 period. Overall, the recommended improvements include increasing lending, optimizing the number of employees, and increasing net income by 518%. For example, in 2023, BSIM needs to optimize its workforce by 30%, increase credit by 593%, and increase net income by 593%.

Conclusion

This study aims to measure the efficiency level of banking companies in Indonesia during the 2021–2023 period using the Data Envelopment Analysis (DEA) method with an intermediation approach. The measurement results show that the average efficiency of the banking industry has increased from 0.67 in 2021 to 0.79 in 2023. However, efficiency achievements among banks still vary, with some banks consistently achieving perfect efficiency, such as BBHI, banks with high efficiency, such as BBCA and PNBN, and banks in the lower-middle to low efficiency category, such as BSIM.

The potential improvement analysis reveals that highly efficient banks still need minor adjustments, particularly in reducing operating costs, optimizing third-party funds, increasing credit distribution, and raising net income in order to achieve perfect efficiency scores. Conversely, banks with medium to low efficiency require greater and more structural improvements, such as a significant increase in productive credit, diversification of revenue sources, and strengthening of profitability. These results also show that digital transformation plays an important role in driving efficiency improvements. Banks that consistently rank in the high efficiency category have generally been early adopters of

digital banking technology, operational process automation, the use of big data and artificial intelligence for risk analysis, and the development of digital-based customer services. This digitalization enables a reduction in operational costs, acceleration of the credit distribution process, and improvement in service quality without significantly increasing the number of employees.

On average, the greatest potential for improvement lies in increasing net income and credit distribution, which can reach more than 400% and 90% respectively in banks with low efficiency scores. Optimizing intermediation functions through digital technology, automation-based cost control, and digital banking product innovation are key to improving the overall efficiency of the banking industry. Thus, although banking efficiency trends in Indonesia are improving, the success of digital transformation will be the main differentiating factor between banks that are able to maintain their competitive advantage. Optimizing intermediation functions through digital technology, automation-based cost control, and digital banking product innovation are key to improving the overall efficiency of the banking industry. Thus, although banking efficiency trends in Indonesia are improving, the success of digital transformation will be the main differentiating factor between banks that are able to maintain their competitive advantage and behind in industry competition.

Limitations

This study has several limitations. First, the use of Data Envelopment Analysis (DEA) as a deterministic and relative method does not account for random error, external shocks, or macroeconomic and regulatory changes that may affect banking performance that may affect banking performance. Second, the analysis is limited to selected financial input and output variables and does not fully capture other dimensions of banking performance, such as risk, service quality, or sustainability. Third, although the study covers the post-pandemic period, it does not explicitly incorporate indicators of digital transformation, focusing instead on efficiency outcomes. Finally, the relatively short observation period of 2021–2023 may limit the assessment of long-term efficiency dynamics.

Future research is encouraged to extend this study in several directions. First, subsequent studies may incorporate stochastic or hybrid efficiency models, such as Stochastic Frontier Analysis (SFA) or DEA–SFA combinations, to account for random error and enhance robustness. Second, future research could expand the set of variables by including risk indicators, digitalization proxies, or ESG-related measures to provide a more

comprehensive assessment of banking efficiency. Third, longer observation periods or panel-based approaches may be employed to capture dynamic efficiency changes over time.

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