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Performance evaluation of Indonesia's large and medium-sized industries using Data Envelopment Analysis method

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ABSTRACT

Performance evaluation is essential for an industry's ability to operate successfully. Efficiency management is becoming crucial and important to enhancing the sustainability of the industry. The industry needs to measure its performance for the following reasons: (i) develop the economy and its operation efficiency in a sustainable way; (ii) supply data for decision-making units (DMUs); and (iii) optimize output using the fewest resources. Performance measurement indicators relate to the performance of the industry itself, such as: added value/cost of production factors, indirect taxes, number of workers, input costs, number of companies, added value/market prices, and production index. The purpose of this research is to measure the performance of large and medium-sized industries (LMIs) in Indonesia. LMIs have a strategic role as the main engine and driver of the economy. Measuring LMI performance is very necessary so that LMI can grow and develop sustainably. Data envelopment analysis (DEA) is a method for measuring performance. DEA is a non-parametric linear programming technique and used to determine comparisons between DMUs with different inputs and outputs. The research results indicate that there are three DMU classification categories, namely: Category 1 (ES = 1), Category 2 (ES = 0.9986-0.9998), and Category 3 (ES = 0.9971-0.9974). The percentages for each category are 50%, 37.5%, and 12.5%.

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1. INTRODUCTION

The industrial sector is essential to Indonesia's economic growth, as it is the backbone and engine of the nation's economy. Foreign exchange profits may arise from the industrial sector's potential to absorb labor and from export operations. Several abilities of the industrial sector are as follows: (i) taking in labor (from businesses that require a lot of labor, capital, knowledge, and technology); (ii) comparatively high output levels; and (iii) its ability to provide links and supplies to other sectors [1]. A business sector known as the processing industry is involved in the mechanical, chemical, or manual conversion of raw materials into finished or semi-finished items, or in producing higher-value goods from low-value raw materials with characteristics more akin to those of the end user. These activities include assembly work and industrial services. The industrial processing sector is divided into four categories: home industries (1-4 employees), small industries (5–19 employees), medium industries (20–99 employees), and large industries (≥ 100 employees) [2].

The processing industry sector's performance was predicted to improve and recover by 3.4% in 2021. This industry contributes to the 3.7% rise in Indonesia's GDP (Gross Domestic Product). One of the pillars of industry's expansion and competitiveness is the expanding ecosystem of industrial activity that fosters the development of industry. Industry boosts employment quality and productivity on a national level. Adequate rules, commercial prospects, resource accessibility, a favorable investment and business environment, and the availability of industrial human resources are all necessary for industrial optimization. Industry has a significant multiplier effect and adds value to the economy. All sectors in Indonesia can benefit from the distinctive outcomes of the industrial sector, which has both forward and backward connections [3].

As the sector with the highest contribution to the national GDP on a consistent basis, the processing industrial sector is important for developing the economy. In addition, export and investment values are achieved, which is a testament to the industrial sector's outstanding performance. The chemical, food and beverage, apparel, electronics, pharmaceutical, and medical equipment industries are included in the seven priority industrial sectors. As this industry contributes over 60% of the country's GDP, the ultimate goal is for Indonesia to rank among the top 10 economies in the world by 2030. The government is paying attention to the industrial sector in order to carry out initiatives and enhance performance to boost the industrial sector's competitiveness and hence spur national economic growth through a variety of strategic initiatives [4].

An important aspect of starting and growing a business is measuring performance. Businesses constantly assess their work performance in light of their advantages and disadvantages. The organization needs to monitor performance for the following reasons: (i) develop the economy and its operation efficiency in a sustainable way; and (ii) supply data for decision-making [5]. Performance evaluation has an important role in the development of a company, including: (i) determining the efficiency and economics of sustainable operations; (ii) providing information as a basis for company decision-making; and (iii) improving the company's operational processes. Its role becomes very important if standards or benchmarks are not presented for evaluation. One technique for evaluating performance is data envelopment analysis, or DEA. Decision-making units (DMUs) are compared with each other using the DEA approach. These DMUs can include business units, decision-making units, companies, organizations, projects, or individuals [6, 7].

The DEA approach is applied to a homogeneous group of DMUs with different inputs and outputs in order to determine their relative efficiency. This concept is a non-parametric linear programming (LP) technique. When evaluating DMUs and allocating resources to support organizational strategy and objectives, the DEA is a useful tool for businesses and organizations. Thus, DEA is a tool for decision support that may be used for planning, controlling, and monitoring management. The efficacy of DEA as a method for benchmarking and performance evaluation to improve organizational operations has been established. In order to compare a unit with its equivalent peers, DEA is used as a benchmarking technique to produce a performance score that shows how far away the unit is from best practices [8].

Businesses in large and medium-sized industries (LMIs) encounter numerous challenges as they grow. The following are several issues: the use of outdated technology in the production process, the dearth of manufacturing facilities, the low quality of raw materials, the low level of sales of products that do not meet the aim, the quality and availability of human resources with inadequate training or education, restricted network of distribution, a lack of advertising, low financial administration, capital resource limitations, restrictions on the acquisition of raw materials, high production prices, and a slow rate of product innovation, weaker IDR compared to USD exchange rates, high inflation, the nation's economy in decline, government initiatives to cut back on public subsidies, unpredictable internal political conditions, a large number of new competitors, fierce competition, quick product innovation and aggressive competitor marketing, a wide range of options for consumers purchasing the same product, low pricing demands from customers, customer complaints, growing raw material prices, the need for high-quality products at prices that are competitive, and a reduction in the supply of raw materials. Consequently, it is imperative to consistently evaluate the performance of large and medium-sized industries (LMIs). This will allow LMI to understand the company's strengths and weaknesses. They'll be able to recognize the opportunities in the industry's business. As a result, they will be better equipped to manage their business and will also be more capable of competing in the global marketplace [1].

The purpose of this research is to measure the performance of large and medium-sized industries (LMIs) in Indonesia. LMIs have a strategic role as the main engine and driver of the economy. Measuring LMI performance is very necessary so that LMI can grow and develop sustainably. The method used in this research is data envelopment analysis (DEA). Several reasons underlying the choice of the DEA method in this research are as follows: (i) DEA is a method for measuring performance; (ii) DEA is the non-parametric linear programming technique; (iii) DEA is used to determine comparisons between DMUs with multiple inputs and outputs; and (iv) DEA is a tool instrument applied to measure the relative effectiveness of the same DMU type. Therefore, DEA serves as a classification and ranking tool.

2. MATERIALS AND METHODS

2.1. Performance Evaluation

Performance evaluation is essential to a company's ability to operate successfully in the face of a dynamic commercial environment. For the business to survive, it is therefore a necessary function. The definition of performance evaluation is the essential procedure for gauging an action's effectiveness and qualification. Efficiency, namely the efficiency determined by the needs and preferences of the client (customer satisfaction), is employed in the framework of performance evaluation. The goal of performance evaluation is to provide information for the company to make decisions while continuously monitoring the economy and efficiency of the business's operations. Performance evaluation is a commonly employed technique to enhance organizational procedures. In the event that criteria or benchmarks are not provided for assessment, this approach becomes crucial [7, 9]. Production efficiency is a key indicator of productivity. Reduced productivity can cause excessive inflation, an unfavorable balance of payments, and sluggish economic growth at the national level. Reduced productivity inside the company may lead to higher production costs and a decline in the company's ability to compete [10].

Efficiency management is becoming more and more crucial to enhancing the sustainability of the chain. The objective of an organization's performance efficiency management strategy is to optimize output using the fewest resources possible or the fewest inputs possible to produce a given quantity of output. It implies that while measuring efficiency, numerous inputs and various outputs would be taken into account [11]. For a firm to grow and flourish, it is essential to evaluate its business performance. Internally assessing a company's existing operations and comparing them to similar organizations and best practices are the two main goals of performance evaluation. In addition to helping a firm better satisfy consumer expectations and requirements, this will also help it: (i) identify its strengths and weaknesses; (ii) better manage its business; and (iii) determine potential business opportunities to improve operations and activities, such as developing new products, services, and processes [12].

2.2. Small, Medium, and Large Sized Industries

A national strategy aims to establish small and medium-sized industries (SMIs). SMIs are crucial for promoting economic expansion through workforce-intensive operations, corporate expansion, and revenue generation. Building SMIs requires strengthening the industries that make up the value chain. The core, allied, and supporting industries make up this group. SMIs with advantageous locations have the ability to transform a comparative advantage into a competitive advantage. This is being accomplished through a number of initiatives, such as (i) strengthening the connections between SMI clusters across industries and (ii) encouraging partnerships between SMIs and large companies. Consequently, it will establish a network structure that fosters cooperation between related, auxiliary, and primary businesses. The term "micro, small, and medium-sized industry" (MSMI) refers to a trading business in which individuals or corporate entities run it. This also includes small- or micro-scale business requirements. Law No. 20, 2008, lists the MSMI regulations. A company with a monthly net worth of less than IDR 50,000,000 is considered to be in the micro-industry. This computation does not account for the value of buildings or commercial space. A firm with a net worth of less than IDR 300,000,000 annually that is run independently, without the assistance of a corporate organization, is considered tiny [13].

Industries classified as large require substantial sums of capital to operate. The kind of goods produced determines this capital. High-tech products require progressively more expensive prices to operate. Additionally, this industry provides goods that other industry types—such as small- or medium-sized industries—need desperately. A major industry is defined under Law No. 3 of 2014 concerning industry as one that employs more than 100 people or has an investment worth of more than IDR 10 billion (excluding land and buildings). Multinational corporations in large industries typically attract investors from different nations. Big businesses work together with associated parties that produce similar goods to these massive industrial products. Finishing touches are typically provided in large industries. Any company will take part in the corporation. There are many different types of partnerships in large industries. The industry's advancement greatly benefits from this relationship [14].

2.3. Data Envelopment Analysis Method

Charnes, Copper, and Rhodes introduced the data envelopment analysis (DEA) method. This method developed the efficiency estimation method invented by Farrell, which involves comparing each production unit to the efficient production frontier. It is not necessary to provide a functional link between the inputs and outputs in order to use this idea [15]. DEA is a benchmarking tool that can be used to evaluate performance. As a result, less effective production techniques are "enveloped" by the best-practice production frontier. Because DEA makes no assumptions regarding the production function's functional structure, it is less likely to lead to misspecifications [16].

Decision-making units (DMUs) that use numerous inputs to produce several outputs might use data envelopment analysis (DEA). This method is a mathematical programming technique to assess the relative efficiency of their operations. In terms of benchmarking and performance evaluation, the DEA approach's viability has been demonstrated. The DEA model under discussion is solved to obtain the efficiency score and benchmarking data for each DMU. The efficiency score is the optimal value of the objective function, and the projection point that the optimal solution yields is in line with the benchmarking data [17]. DEA represents a method for nonparametric linear programming. The goal of DEA is to assess a set of similar organizations or decision-making units (DMUs) in terms of their relative efficiency. The technique known as DEA uses a variety of inputs and outputs to calculate the efficiency score. An efficiency frontier is created using a set of effective DMUs that serve as best practices, based on the efficiency index. Measurement of the distance from the efficiency frontier allows one to determine the efficiency level of inefficient DMUs. A production process can serve as an appropriate representation of the DEA approach [18, 19].

The DEA method is used to compare the technical efficiency (TE) of various decision-making units (DMUs). TE is a term used to describe the optimal use of resources during the production process, much like physical productivity. A certain set of inputs yields the maximum output. Physical indications are the main focus. Constant returns to scale (CRS) and variable returns to scale (VRS) are two alternative hypotheses that allow for the non-parametric development of a DEA production frontier. Furthermore, an input-oriented model is applied when DMUs have greater control over inputs. The aim is to minimize resource utilization while fulfilling a particular productivity level. On the other hand, when DMUs concentrate on optimizing output from a fixed level of inputs, they apply an output-oriented approach [20–22].

Equations (1) through (4) of the linear programming formula are present in the DEA model. The model's output criteria are specified at the current level and are designed to minimize input.

$$\theta^* = \min \theta \tag{1}$$

.subjected to the following restrictions:

$$\sum_{j=1}^{n} Xij\, \lambda j \ \leq \ \theta\, Xi0\,, \qquad i = 1, \dots, m \tag{2}$$

$$\sum_{j=1}^{n} Yrj\, \lambda j \ \geq \ Yr0\,, r = 1, \dots, s \tag{3}$$

$$\sum_{j=1}^{n} \lambda j = 1 \tag{4}$$

$$\lambda j \ \geq \ 0 \qquad j = 1, \dots, n$$

Equation (1) represents the objective function that maintains existing output levels while minimizing inputs. Equation (2) represents the input constraint, which contains several restrictions for every input. Equation (3) represents the output constraint, which contains several restrictions for each output. The unknown weights (λj) are shown in equation (4).

Among the n mentioned DMUs is DMU0. Xi0 and Yr0, respectively, represent the r-input and r-output of DMU0. λj represents the unknown weight, where j = 1,..., n. The solution variable, with the notation θ, represents the efficacy value. If θ is equal to 1, then the solution will be feasible. θ* ≤ 1 at its optimal value. If θ* = 1, then DMU0 is situated at the optimal criteria limit, indicating that a proportionate reduction in the current input level is not possible. The DMU0 is situated at the edge. If θ* is less than 1, then the solution is not feasible. Therefore, the same proportion of θ* can reduce the input. To achieve the same amount of output, less input is required [23]. Notations of the DEA model are presented in Table 1.

Table 1. Descriptions for DEA symbols

Notations	Descriptions	Notations	Descriptions
θ*	Optimal value/solution	Yrj	jth DMU's ith outputs
θ	A decision variable/DEA efficiency score	r	Number of outputs
DMUj	Decision-making units (DMUs)	s	Last number of outputs
j	Number of DMUs	λj	Unknown weights of DMUj
n	Last number of DMUs	DMUo	One of the n DMUs under evaluation
Xij	jth DMU's ith inputs	Xi0	ith input for DMUo
i	Number of inputs	Yr0	rth output for DMUo
m	Last number of inputs		

The DEA model arises from three constraints. The model can be expressed in equations (5) through (8). The objective function is represented in equation (1). This function minimizes inputs while maintaining current output levels. These exactly have m+s+1 constraints. The first constraint consists of m-different constraints for each other's input (Eq. 6). The second constraint consists of s-different constraints for each other's output (Eq. 7). There is just one constraint remaining (Eq. 8), which is the quantity of unknown weights (λj). Table 2 provides a description of the notation used in equations (5) through (8).

$$\theta^* = \min \theta \tag{5}$$

Subject to

$$\lambda_1 x_{i1} + \lambda_2 x_{i2} + \dots \lambda_o x_{io} + \dots + \lambda_n x_{in} \leq \theta x_{i0} \quad i = 1, 2, \dots, m \tag{6}$$

$$\lambda_1 y_{r1} + \lambda_2 y_{r2} + \dots \lambda_o y_{ro} + \dots + \lambda_n y_{rn} \geq y_{r0} \quad r = 1, 2, \dots, s \tag{7}$$

$$\lambda_1 + \lambda_2 + \dots \lambda_o + \dots + \lambda_n = 1 \tag{8}$$

$$\lambda_j \geq 0, j = 1, 2, \dots, n$$

Table 2. Description of equation notation (5) through (8)

Notations	Descriptions	Notations	Descriptions
θ*	Optimal value/solution	Yrj	jth DMU's ith outputs
θ	A decision variable/DEA efficiency score	r	Number of outputs
DMUj	Decision-making units (DMUs)	s	Last number of outputs
j	Number of DMUs	λj	Unknown weights of DMUj
n	Last number of DMUs	DMUo	One of the n DMUs under evaluation
Xij	jth DMU's ith inputs	Xi0	ith input for DMUo
i	Number of inputs	Yr0	rth output for DMUo
m	Last number of inputs		

Equations (9) through (16) provide a more detailed description of the DEA model. Equation (9) represents the objective function that maintains existing output levels while minimizing inputs. Equations (10) and (11) represent the first and second input constraints. The last input constraint is presented in equation (12).

Equations (13) and (14) represent the first and second output constraints. The last output constraint is presented in equation (15). The quantity of unknown weights (λj) is presented in equation (16). Table 3 provides a description of the notation used in equations (9) through (16).

$$\theta^* = \min \theta \tag{9}$$

Subject to

$$\lambda_1 x_{11} + \lambda_2 x_{12} + \dots \lambda_o x_{1o} + \dots + \lambda_n x_{1n} \leq \theta x_{10} \quad \text{(1st input)} \tag{10}$$

$$\lambda_1 x_{21} + \lambda_2 x_{22} + \dots \lambda_o x_{2o} + \dots + \lambda_n x_{2n} \leq \theta x_{20} \quad \text{(2nd input)} \tag{11}$$

$$\dots$$

$$\lambda_1 x_{m1} + \lambda_2 x_{m2} + \dots \lambda_o x_{mo} + \dots + \lambda_n x_{mn} \leq \theta x_{m0} \quad \text{(mth input, last input)} \tag{12}$$

$$\lambda_1 y_{11} + \lambda_2 y_{12} + \dots \lambda_o y_{1o} + \dots + \lambda_n y_{1n} \geq y_{r0} \quad \text{(1st output)} \tag{13}$$

$$\lambda_1 y_{21} + \lambda_2 y_{22} + \dots \lambda_o y_{2o} + \dots + \lambda_n y_{2n} \geq y_{r0} \quad \text{(2nd output)} \tag{14}$$

$$\dots$$

$$\lambda_1 y_{r1} + \lambda_2 y_{r2} + \dots \lambda_o y_{ro} + \dots + \lambda_n y_{rn} \geq y_{r0} \quad \text{(mth output, last output)} \tag{15}$$

$$\lambda 1 + \lambda 2 + \dots \lambda o + \dots + \lambda n = 1 \tag{16}$$

$$\lambda j \geq 0, j = 1, 2, \dots, n$$

Table 3. Description of equation notation (9) through (16)

Notations	Descriptions	Notations	Descriptions
θ*	Optimal value/solution	y_{11}	1st DMU's 1st output
θ	A decision variable/DEA efficiency score	y_{12}	2nd DMU's 1st output
λj	Unknown weights of DMUj	y_{1o}	0th DMU's 1st output
DMUj	Decision-making units (DMUs)	y_{1n}	1th DMU's 1st output
j	Number of DMUs	y_{21}	1st DMU's 2nd output
n	Last number of DMUs	y_{22}	2nd DMU's 2nd output
λ_1	1st unknown weight	y_{2o}	0th DMU's 2nd output
λ_2	2nd unknown weight	y_{2n}	nth DMU's 2nd output
λ_0	0th unknown weight	y_{r1}	1st DMU's rth output
λ_n	nth unknown weight	y_{r2}	2nd DMU's rth output
x_{11}	1st DMU's 1st input	y_{ro}	0th DMU's rth output
x_{12}	2th DMU's 1st input	y_{rn}	nth DMU's rth output
x_{1o}	0th DMU's 1st input	*DMUo*	One of the n DMUs under evaluation
x_{1n}	nth DMU's 1st input	x_{10}	1st input for DMUo
x_{21}	1st DMU's 2nd input	x_{20}	2nd input for DMUo
x_{22}	2nd DMU's 2nd input	x_{m0}	mth input, last input for DMUo
x_{2o}	0th DMU's 2nd input	y_{10}	1st output for DMUo
x_{2n}	nth DMU's 2nd input	y_{20}	2nd output for DMUo
x_{m1}	1st DMU's mth input, last input	y_{r0}	rth output, last output for DMUo
x_{m2}	2nd DMU's mth input, last input		
x_{mo}	0th DMU's mth input, last input		
x_{mn}	nth DMU's mth input, last input		

2.4. Research Methodology

The following are the steps that this research uses to solve problems: phases 1 (research design and definition), phases 2 (preparation, data gathering, and data assessment), phases 3 (data processing), phases 4 (result analysis), and phases 5 (conclusion). Phases of preparation, gathering, and assessing data, namely: (i) categorizing input and output data for large and medium-sized industries (LMIs); and (ii) figuring out LMI input, output, and DMU (decision-making unit) data. The steps involved in data processing are as follows: (i) standardization of input and output data; (ii) constraints; and (iii) efficiency. The DMU and DMU under evaluation data are entered into Microsoft Excel spreadsheets. Microsoft Excel is a solver for DMU efficiency calculations. The analysis of results includes: (i) efficient DMU; (ii) DMU is inefficient; (iii) DMU classification;

(iv) factors causing increases and decreases in LMIs performance; and (v) LMIs development strategy. Figure 1 displays the research method flowchart.

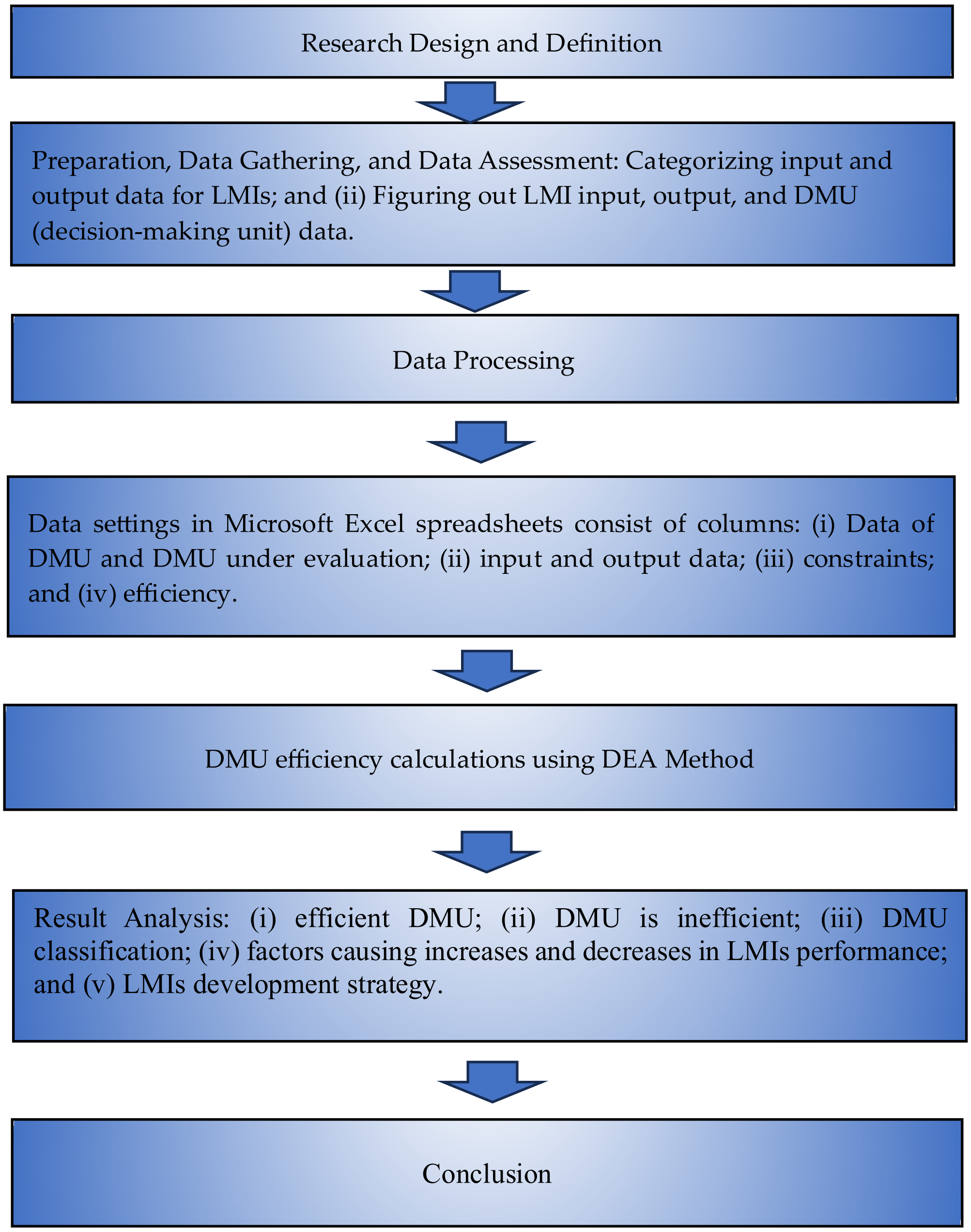

Figure 1. Research method flowchart

3. RESULTS

3.1. Input and Output Variables

The data of Indonesia's large and medium-sized industries (LMIs) in 2021 was applied in this research [24]. These data include: added value/cost of production factors, indirect taxes, number of workers, input costs, number of companies, proportion of workers in the manufacturing industrial sector, added value/market prices, and production index. DEA is a linear programming technique that deals with many efficiency parameters within an integrated model. Multiple efficiency measurements are associated with input and output variables. The variables that are typically minimized are called input variables. These include things like expenses, labor, materials consumed, etc. The variables that are typically maximized are called output variables. Examples of these are profit, revenue, and products. Prior to applying the DEA approach, input and output parameters are categorized and selected [13]. Based on these regulations, six input variables (X1 to X6) and two output variables (Y1 and Y2) can be determined, as shown in Table 4.

Table 4. Input and output variables

Input (I) - Output (O)	Variable	Input and output types	Units
Input I-1	X1	Added value/cost of production factors	Billions of rupiah
Input I-2	X2	Indirect taxes	Billions of rupiah
Input I-3	X3	Number of workers	Person
Input I-4	X4	Input costs	Billions of rupiah
Input I-5	X5	Number of companies	Units
Input I-6	X6	Proportion of workers in the manufacturing industrial sector	Percent
Output O-1	Y1	Added value / market prices	Billions of rupiah
Output O-2	Y2	Production index	Index

3.2. Industrial Classification Based on KBLI and DMUs

The Standard Classification of Indonesian Business Fields (Klasifikasi Baku Lapangan Usaha Indonesia, or KBLI) is one of the standard classifications published by the Central Statistics Agency (BPS) for economic activities. A strategy of grouping utilized in statistical procedures and economic communication is called classification. When data is classified, it is arranged into classes that are as similar to one another as feasible based on predetermined guidelines or standards. KBLI offers an extensive collection of frameworks for classifying economic activities in Indonesia, making it usable for conducting statistics, basic planning, policy evaluation, and licensing [25].

Table 5. Industrial classification (IC) based on KBLI and DMUs

DMUs	Code	Industrial classification - KBLI	DMUs	Code	Industrial classification - KBLI
KI-10	10	Food	KI-22	22	Plastic, rubber, and rubber-based products
KI-11	11	Beverages	KI-23	23	Minerals without metals
KI-12	12	Tobacco processing	KI-24	24	Primary metal
KI-13	13	Textiles	KI-25	25	Items made of metal, not machinery and equipment
KI-14	14	Clothes	KI-26	26	Electronics, optics, and computers
KI-15	15	Leather, leather goods, and footwear	KI-27	27	Electrical equipment
KI-16	16	Wood, furniture constructed of wood and cork, and objects woven from bamboo, rattan, and similar materials	KI-28	28	Machinery and equipment ytdl
KI-17	17	Paper products	KI-29	29	Automobiles, semi-trailers, and trailers
KI-18	18	Printing and duplicating recorded media	KI-30	30	Another modes of transportation
KI-19	19	Coal and petroleum refining products	KI-31	31	Furniture
KI-20	20	Chemicals and products derived from them	KI-32	32	Another processing
KI-21	21	Pharmaceuticals, chemical medicinal products, and traditional medicines	KI-33	33	Services for installing and repairing machinery and equipment

ISIC (International Standard Industrial Classification of All Economic Activities) serves as the foundation for the industrial classification utilized in the processing industry survey. Under the name Standard Classification of Indonesian Business Fields (Klasifikasi Baku Lapangan Usaha Indonesia, KBLI), this classification has been adjusted to better suit Indonesia's demands. The standard business field code of an industrial company is determined by its primary production, or the type of commodity produced with the highest value. If an industrial company produces two or more types of commodities with the same value, then the main production is the commodity produced in the largest quantity [24]. The DEA method applies a decision-making unit (DMU) to perform each process, unity, and business activity in its calculation [23]. In this research, KBLI industries are DMUs. Furthermore, the identity of each DMU is adjusted to the KBLI industry code. The DMU identity for the code 10 food industry is KI-10, the DMU identity for the code 11 beverage industry is KI-11, and so on. Table 5 presents 24 industry classifications based on KBLI and Decision-Making Units (DMUs).

3.3. Input and Output Data

An overview of all the data utilized in this research is given in Table 6. There are two output variables (Y1 and Y2), six input variables (X1 to X6), and 24 DMUs in this set of data.

Table 6. Input and output data

No.	DMUs	Input data						Output data	
		X1	X2	X3	X4	X5	X6	Y1	Y2
1	KI-10	705,110	14,502	989,741	1,285,457	7,498	3.86	719,613	217.55
2	KI-11	36,231	1,909	91,205	33,848	642	0.37	38,140	151.18
3	KI-12	148,186	4,043	246,587	140,613	635	0.33	152,229	122.79
4	KI-13	104,916	1,618	391,007	167,398	1,988	0.82	106,535	60.29
5	KI-14	125,320	1,752	749,183	146,417	2,005	2	127,071	139.02
6	KI-15	85,054	483	568,552	94,345	751	0.71	85,536	127.17
7	KI-16	38,837	716	249,692	47,129	1,255	1.25	39,554	62.25
8	KI-17	124,094	964	160,494	152,814	813	0.19	125,058	94.98
9	KI-18	20,464	282	65,817	16,508	874	0.26	20,746	135.29
10	KI-19	139,249	216	21,679	188,792	126	0.04	139,464	0
11	KI-20	302,991	9,486	254,976	549,435	1,840	0.28	312,477	128.86
12	KI-21	71,452	899	83,532	62,793	384	0.12	72,351	340.21
13	KI-22	123,106	2,522	443,344	200,387	2,600	0.45	125,628	91.50
14	KI-23	105,498	1,627	180,767	124,602	1,731	0.68	107,124	106.89
15	KI-24	264,785	1,002	155,596	317,872	562	0.17	265,787	175.73
16	KI-25	70,339	1,361	180,635	112,093	1,592	0.46	71,700	136.52
17	KI-26	55,719	643	136,101	46,151	329	0.11	56,362	60.65
18	KI-27	138,915	627	136,154	150,567	564	0.14	139,541	164.73
19	KI-28	54,831	931	89,381	46,853	801	0.16	55,762	201.70
20	KI-29	203,471	605	257,376	177,209	754	0.16	204,076	178.44
21	KI-30	79,270	828	117,152	128,736	450	0.19	80,099	73.53
22	KI-31	35,137	412	172,209	33,813	1,375	0.65	35,549	92.36
23	KI-32	35,177	479	222,182	28,493	897	0.62	35,656	67.94
24	KI-33	11,967	305	30,204	5,611	322	0.15	12,272	40.67

3.4. Standardization of Input and Output Data

Data standardization is carried out to standardize data values whose format is inconsistent when input using a certain format, until all data becomes standard. The standardization of the data is presented in Table 7.

3.5. Utilizing Microsoft Excel Spreadsheets for Data Processing

A Microsoft Excel spreadsheet is used to organize research data and results, as follows: DMUs, input and output data, unknown weights (λ), constraints, reference set, and DMU under evaluation. These components are presented in Table 8 and Table 9. The input-oriented DEA Envelopment Model is used to calculate efficiency scores. Next, a score for each DMU's efficiency was obtained by using the MS Excel Solver function.

Table 7. Standardization of data

No.	DMUs	Input Data						Output Data	
		X1	X2	X3	X4	X5	X6	Y1	Y2
1	KI-10	693,143	14,286	968,062	1,279,846	7,372	3.82	707,341	218
2	KI-11	24,264	1,693	69,526	28,237	516	0.33	25,868	151
3	KI-12	136,219	3,827	224,908	135,002	509	0.29	139,957	123
4	KI-13	92,949	1,402	369,328	161,787	1,862	0.78	94,263	60
5	KI-14	113,353	1,536	727,504	140,806	1,879	1.96	114,799	139
6	KI-15	73,087	267	546,873	88,734	625	0.67	73,264	127
7	KI-16	26,870	500	228,013	41,518	1,129	1.21	27,282	62
8	KI-17	112,127	748	138,815	147,203	687	0.15	112,786	95
9	KI-18	8,497	66	44,138	10,897	748	0.22	8,474	135
10	KI-19	127,282	0	0	183,181	0	0.00	127,192	0
11	KI-20	291,024	9,270	233,297	543,824	1,714	0.24	300,205	129
12	KI-21	59,485	683	61,853	57,182	258	0.08	60,079	340
13	KI-22	111,139	2,306	421,665	194,776	2,474	0.41	113,356	92
14	KI-23	93,531	1,411	159,088	118,991	1,605	0.64	94,852	107
↓									
↓									
22	KI-31	23,170	196	150,530	28,202	1,249	0.61	23,277	92
23	KI-32	23,210	263	200,503	22,882	771	0.58	23,384	68
24	KI-33	0	89	8,525	0	196	0.11	0	41

Table 8. Data preparation in microsoft excel spreadsheet

No.	DMUs	X1	X2	X3	X4	X5	X6	Y1	Y5	λ	Eff.
1	KI-10	693,143	14,286	968,062	1,279,846	7,372	3.82	707,341	218	0	1
2	KI-11	24,264	1,693	69,526	28,237	516	0.33	25,868	151	0	1
3	KI-12	136,219	3,827	224,908	135,002	509	0.29	139,957	123	0	1
4	KI-13	92,949	1,402	369,328	161,787	1,862	0.78	94,263	60	0	0.9993
5	KI-14	113,353	1,536	727,504	140,806	1,879	1.96	114,799	139	0	0.9997
6	KI-15	73,087	267	546,873	88,734	625	0.67	73,264	127	0	0.9994
7	KI-16	26,870	500	228,013	41,518	1,129	1.21	27,282	62	0	0.9974
8	KI-17	112,127	748	138,815	147,203	687	0.15	112,786	95	0	0.9996
9	KI-18	8,497	66	44,138	10,897	748	0.22	8,474	135	0	1
10	KI-19	127,282	0	0	183,181	0	0.00	127,192	0	0	1
11	KI-20	291,024	9,270	233,297	543,824	1,714	0.24	300,205	129	0	1
12	KI-21	59,485	683	61,853	57,182	258	0.08	60,079	340	0	1
13	KI-22	111,139	2,306	421,665	194,776	2,474	0.41	113,356	92	0	1
14	KI-23	93,531	1,411	159,088	118,991	1,605	0.64	94,852	107	0	0.9995
↓											
↓											
22	KI-31	23,170	196	150,530	28,202	1,249	0.61	23,277	92	0	0.9973
23	KI-32	23,210	263	200,503	22,882	771	0.58	23,384	68	0	0.9971
24	KI-33	0	89	8,525	0	196	0.11	0	41	1	1

Table 9. Constraints, reference set, DMU under evaluation, and efficiency

No.	Constraints	Reference Set			DMU Under Evaluation	Efficiency
1	Input1	0	≤	0	24	1
2	Input2	89	≤	89		
3	Input3	8525	≤	8525		
4	Input4	0	≤	0		
5	Input5	196	≤	196		
6	Input6	0	≤	0		
7	Output1	0	≥	0		
8	Output2	41	≥	41		
9	∑ʎ	1				

3.6. Analysis of Efficient and Inefficient DMUs

The efficient and inefficient status of the DMUs can be determined based on the efficiency score results. An efficient DMU has an efficiency score equal to one, and an inefficient DMU has a score of less than one. The factors that cause DMUs to have efficient and inefficient statuses are explained as follows: An efficient DMU always generates more outputs with equal input consumption or produces a given quantity of outputs with lower input consumption [23]. In contrast, an inefficient DMU consumes more input to produce a given amount of output. Table 10 presents the analysis of these DMU statuses. There are 12 efficient DMUs, namely: KI-10, KI-11, KI-12, KI-18, KI-19, KI-20, KI-21, KI-22, KI-24, KI-28, KI-29, and KI-33. Inefficient DMUs also consist of 12 DMUs, namely: KI-13, KI-14, KI-15, KI-16, KI-17, KI-23, KI-25, KI-26, KI-27, KI-30, KI-31, and KI-32.

Table 10. Analysis of efficient and inefficient DMUs

No.	DMUs	Efficiency Score	Status	No.	DMUs	Efficiency Score	Status
1	KI-10	1	Efficient	13	KI-22	1	Efficient
2	KI-11	1	Efficient	14	KI-23	0.9995	Inefficient
3	KI-12	1	Efficient	15	KI-24	1	Efficient
4	KI-13	0.9993	Inefficient	16	KI-25	0.9992	Inefficient
5	KI-14	0.9997	Inefficient	17	KI-26	0.9986	Inefficient
6	KI-15	0.9994	Inefficient	18	KI-27	0.9998	Inefficient
7	KI-16	0.9974	Inefficient	19	KI-28	1	Efficient
8	KI-17	0.9996	Inefficient	20	KI-29	1	Efficient
9	KI-18	1	Efficient	21	KI-30	0.9991	Inefficient
10	KI-19	1	Efficient	22	KI-31	0.9973	Inefficient
11	KI-20	1	Efficient	23	KI-32	0.9971	Inefficient
12	KI-21	1	Efficient	24	KI-33	1	Efficient

3.7. DMU Classification

The relative effectiveness of the same type of DMU is measured using a tool called Data Envelopment Analysis (DEA). The concept of the approach is to specify the relative effectiveness of the production frontier by maintaining the DMU inputs or outputs constant. This process applies a mathematical model and statistical data. The DEA model is used to project each DMU onto the DEA production frontier. The relative effectiveness of each DMU is then calculated by comparing its divergence from the DEA effective frontier [26]. By comparing DMU outcomes, DEA serves as a classification and ranking tool. The consistency of the results demonstrates the validity of the DEA as a classification and ranking tool. DEA is therefore validated as a method of ranking and classification [27].

Figure 2 presents the efficiency score (ES) value for each decision-making unit (DMU). The x axis shows the type of DMUs, and the y axis shows the ES value for each DMU. The efficient and inefficient status of the DMUs can be determined based on the efficiency score results. An efficient DMU has an ES equal to one (high score), and an inefficient DMU has an ES of less than one (low score). The factors that cause DMUs to have high and low efficiency scores are explained as follows: A DMU with high efficiency scores always generates more outputs with equal input consumption or produces a given quantity of outputs with lower input consumption [23]. In contrast, a DMU with low efficiency scores consumes more input to produce a given amount of output. This research indicated that there are 12 DMUs with high efficiency scores and 12 DMUs with low efficiency scores.

The DMU efficiency scores are shown in Figure 2, arranged from highest to lowest. DMU clustering is found using this strategy. Then, as a foundation for classifying categories, a threshold can be established for every category. First, there is a threshold of 1 for Category 1. The next criterion for Category 2 is in the range of 0.9986 to 0.9998. Lastly, the range of 0.9971 to 0.9974 is the threshold for category 3. Category 1 consists of 12 DMUs, namely: KI-10, KI-11, KI-12, KI-19, KI-20, KI-21, KI-22, KI-24, KI-28, KI-29, KI-33, and KI-18. Category 2 consists of 9 DMUs, namely: KI-27 (0.9998), KI-14 (0.9997), KI-17 (0.9996), KI-23 (0.9995), KI-15 (0.9994), KI-13 (0.9993), KI-25 (0.9992), KI-30 (0.9991), and KI-26 (0.9986). Category 3 consists of 3 DMUs, namely: KI-16 (0.9974), KI-31 (0.9973), and KI-32 (0.9971). Table 11 presents the classification of these DMUs. This table explains the type of category classifications, thresholds (SE, DMU, and efficiency score), amount of DMUs for each category, and percentage of each category. Category classifications are Category 1 (ES = 1), Category 2 (ES = 0.9986-0.9998), and Category 3 (ES = 0.9971-0.9974). The percentages for each category are 50% (12/24 x 100%), 37.5% (9/24 x 100%), and 12.5% (3/24 x 100%), respectively.

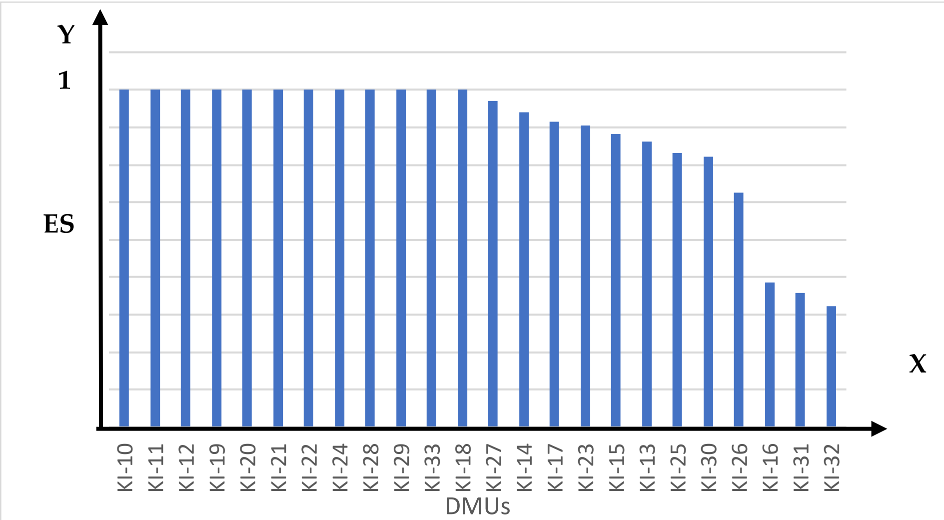

Figure 2. Efficiency score (SE) for each DMU

Table 9. DMU classification

Type of Category Classification	Threshold SE	DMU and Efficiency Score	Amount	Perc. (%)
Category 1	1	KI-10 (1), KI-11 (1), KI-12 (1), KI-19 (1), KI-20 (1), KI-21 (1), KI-22 (1), KI-24 (1), KI-28 (1), KI-29 (1), KI-33 (1), and KI-18 (1).	12	50
Category 2	0.9986- 0.9998	KI-27 (0.9998), KI-14 (0.9997), KI-17 (0.9996), KI-23 (0.9995), KI-15 (0.9994), KI-13 (0.9993), KI-25 (0.9992), KI-30 (0.9991), and KI-26 (0.9986).	9	38
Category 3	0.9971-0.9974	KI-16 (0.9974), KI-31 (0.9973), and KI-32 (0.9971).	3	13

3.8. Large and Medium-Sized Industry Classification Categories

Based on the DMU classification, the Large and Medium-Sized Industry (LMI) classification categories can be determined as presented in Table 12. The types of industries included in category 1 are as follows: (i) food; (ii) beverages; (iii) tobacco processing; (iv) coal and petroleum refining products; (v) chemicals and products derived from them; (vi) pharmaceuticals, chemical medicinal products, and traditional medicines; (vii) plastic, rubber, and rubber-based products; (viii) primary metal; (ix) machinery and equipment ytdl; (x) automobiles, semi-trailers, and trailers; (xi) services for installing and repairing machinery and equipment; (xii) printing and duplicating recorded media. The types of industries included in category 2 are as follows: (i) textiles, (ii) clothes, (iii) leather, leather goods, and footwear; (iv) wood, furniture constructed of wood and cork, and objects woven from bamboo, rattan, and similar materials; (v) paper products; (vi) minerals without metals; (vii) items made of metal, not machinery and equipment; (viii) electronics, optics, and computers; and (ix) electrical equipment. The types of industries included in category 3 are as follows: (i) another mode of transportation; (ii) furniture; and (iii) another processing.

Table 10. Large and medium-sized industry classification categories

No.	Classification	Industry Classification - KBLI
1	Category 1	Food (KI-10), Beverages (KI-11), Tobacco processing (KI-12), Coal and petroleum refining products (KI-19), Chemicals and products derived from them (KI-20), Pharmaceuticals, chemical medicinal products, and traditional medicines (KI-21), Plastic, rubber, and rubber-based products (KI-22), Primary metal (KI-24), Machinery and equipment ytdl (KI-28), Automobiles, semi-trailers, and trailers (KI-29), Services for installing and repairing machinery and equipment (KI-33), and Printing and duplicating recorded media (KI-18).
2	Category 2	Textiles (KI-13), Clothes (KI-14), Leather, leather goods, and footwear (KI-15), Wood, furniture constructed of wood and cork, and objects woven from bamboo, rattan, and similar materials (KI-16), Paper products (KI-17), Minerals without metals (KI-23), Items made of metal, not machinery and equipment (KI-25), Electronics, optics, and computers (KI-26), and Electrical equipment (KI-27).
3	Category 3	Another modes of transportation (KI-30), Furniture (KI-31), and Another processing (KI-32).

3.9. Analysis of Improvements and Decreases in LMI Performance

According to the analysis's findings (applying a cause-and-effect matrix), the factors causing the increase and decrease in the performance of large and medium-sized industries (LMIs) can be identified. The following factors contributed to LMI's improved performance: price reductions, variable product prices (bargaining), availability of newly available technologies, strategic location, high-quality products, responsiveness to market demands, focused marketing skills, benchmarking to evaluate the state of the market, accessibility of human resources, as well as their knowledge, abilities, and experience, accessibility of raw supplies, machines, and manufacturing sites that comply with requirements, accessibility of working capital, accessibility of bank credit, the role of non-governmental organizations, the function of the local government and relevant institutions, the presence of institutions for research and development, education, and training; the possibility of exporting goods abroad; purchasing power; excellent relationships with suppliers; assistance in selecting raw material suppliers; the entry of competitors that promotes an increase in both quantity and quality; and having excellent relationships with customers.

The factors that cause a decline in LMI performance are as follows: poor marketing strategy, the quantity of goods sold that don't meet the goal, the standard and accessibility of poorly educated and trained human resources, the lack of manufacturing facilities, the use of outdated technology in the production process, poor raw material quality, restrictions in obtaining raw resources, limitations on capital resources, poor financial management, high production costs, and sluggish product innovation, insufficient network of distribution, the deficiency in promotions, reduced rate of the IDR relative to the USD, a high rate of inflation, a deteriorating national economy, government initiatives to cut back on public subsidies, an unpredictable domestic political environment, competitive pressure, the entry of numerous new competitors, Customers' demands for low prices, competitors' aggressive marketing campaigns, quick product innovation, and a large range of options for the same product, the need for high-quality goods at prices that are becoming more competitive, consumer complaints, increasing costs for basic resources, and a decrease in their supply [1].

3.10. Large and Medium-Sized Industrial Business Development

Regarding the classification categories of Large and Medium-Sized Industry (LMI), industries in category 1 have effective performance. Meanwhile, industries in categories 2 and 3 have ineffective performance. Therefore, in order to be effective, efforts must be made to develop the businesses of industries in these two categories. In general, two important factors are required for developing LMI businesses, namely, internal and external factors. The company's strengths and weaknesses are determined by internal factors. The opportunities and threats facing the companies are determined by external factors. Identification of internal factors of LMI is presented in Table 13. Strengths of internal factors consist of (a) the market's needs; (b) brainstorming; (c) targeted marketing; (d) human resources (HRs); (e) HR expertise, skills, and experience; (f) the production process; (g) engines and production facilities; and (h) capital, credit, outcome, location, and pricing. Weaknesses of internal factors consist of (a) marketing strategy; (b) sales target; (c) both human resources and quality; (d) personnel with education and training; (e) raw material quality; (f) production facilities; (g) technology of the production process; restrictions on raw materials; and financial resources; (h) distribution network; (i) production expenses; and (j) product innovation.

Table 11. Internal factors

Strengths	Weaknesses
a. The market's needs must be taken into consideration.	a. Poor marketing strategy
b. Brain-marking should be done to assess the state of the market.	b. Low sales of non-target products
c. Targeted marketing should be able to be executed.	c. Low quality of trained and educated human resources.
d. Human resources (HRs) should be available.	d. Low presence of personnel with education and training.
e. HR expertise, skills, and experience should be obtained.	e. Inadequate raw material quality.
f. The production process should be followed.	f. Facilities for production are still lacking.
g. Engines and production facilities that adhere to standards should be used.	g. Outdated technology used in the production process; restrictions on obtaining raw materials; and limitations on financial resources.
h. Working capital accessibility, bank credit accessibility, product quality, local and export product scales, strategic location, product pricing flexibility (bargaining), and the availability of price breaks.	h. There is still a deficiency in the distribution network in some regional areas.
	i. Production expenses are high.
	j. Product innovation is sluggish in comparison to competitors.

The identification of external factors in LMI is presented in Table 14. The opportunities of external factors consist of (a) the role of local government, related agencies, and non-governmental organizations (NGOs); (b) institutions of research, development, education, and training; (c) management information systems; (d) new technologies; (e) population growth; (f) export opportunities; (g) relationships with suppliers and customers; (h) the emergence of competitors; and (i) the number of regular, new, and non-fixed customers. Threats from external factors consist of (a) the inflation rate; (b) the country's economy; (c) new competitors; (d) business competition; (e) goods invention; (f) promotion; (g) product price; (h) customers' desire; (i) superior product; (j) customer complaints; (k) raw material price; and (l) raw material [28].

Table 12. External factors

Opportunities	Threats
a. The role of local government and related agencies.	a. A high rate of inflation.
b. The existence of research and development institutes.	b. The country's economy is declining.
c. The existence of education and training institutions.	c. A large number of new competitors have emerged.
d. The role of non-governmental organizations (NGOs).	d. The competition is fiercely strict.
e. The sophistication of management information systems.	e. Quick invention in competing goods.
f. The adoption of new technologies.	f. Fierce competition promotion.
g. The rapid growth of the population.	g. A variety of ways for customers to purchase the same item.
h. Export opportunities overseas.	h. Customers' desire for low prices.
i. Positive relationships with suppliers. Assistance in choosing raw material and material suppliers.	i. Requirements for a superior product at a more affordable pricing.
j. The emergence of competitors prompts an increase in quantity and quality.	j. Customer complaints that are filed.
k. A large number of regular customers.	k. Price increases for raw materials.
l. A large number of new and non-fixed customers.	l. Reduction in raw material availability.
m. A positive rapport with customers.	

5. CONCLUSION

An efficient DMU has an efficiency score equal to one, and an inefficient DMU has a score less than one. There are 12 efficient DMUs and 12 inefficient DMUs. Both types of DMU have the same percentage, namely, 50% each. There are three DMU classification categories based on efficiency score (SE), namely: Category 1 (SE = 1), Category 2 (SE = 0.9986-0.9998), and Category 3 (SE = 0.9971-0.9974). The percentages for each category are 50%, 37.5%, and 12.5%. Various factors are needed to develop large and medium-sized industries (LMI). In general, there are two important factors in developing an LMI business, namely: (a) internal factors that determine the strengths and weaknesses of an LMI business; and (b) external factors that determine LMI business opportunities and threats.

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