DETERMINING THE IMPORTANCE OF PERFORMANCE INDICATORS FOR ANALYZING PRODUCTION SECTOR EFFICIENCY USING THE DEA METHOD – A CASE STUDY OF VENDOM COMPANY

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ORIGINAL SCIENTIFIC PAPER

Received: 21 October 2026.
Accepted: 10 November 2026.
Published: 16 November 2026.
DOI: https://doi.org/10.63395/STEDConf15022026179DJ185

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Citation: Đukanović, S. (2026). Determining the Importance of Performance Indicators for Analyzing Production Sector Efficiency Using the DEA Method – A Case Study of Vendom Company. In Kojić, D. & Sredić. D. (eds.) *Conference proceedings, XV International Conference on Social and Technological Development: STED 2026* (pp. 185-197). Trebinje, B&H: University PIM.

ABSTRACT

The efficiency of the production sector largely refers to the effectiveness of management practices in optimizing company performance while minimizing resources and costs, and it represents a key factor in determining productivity and the overall success of a company. Inefficient production and overall business operations do not only represent a waste of valuable time, but also significantly affect the company's market positioning, profitability, customer satisfaction, and the overall business image of the company. For the analysis of the production sector efficiency of the real company Vendom, operating in the metal industry sector, this paper applies the DEA method, or Data Envelopment Analysis, which is considered the most successful and most widely used non-parametric method for performance measurement and efficiency analysis. It is a data-based method for measuring the efficiency of complex entities that use diverse inputs to generate diverse outputs. Considering the availability of data, typical indicators were selected as input and output variables: material costs, labor costs, number of work operations, etc. (as the inputs), and total added value (as the output). Prior to selecting the input and output units, data preprocessing was conducted, and inputs and outputs were created as derived indicators by aggregating the corresponding basic cost or revenue indicators. The obtained correlation coefficients indicated a high degree of interrelationship among the selected variables, confirming the justification for applying the DEA method in efficiency analysis. The results showed that it is possible to improve the efficiency of the production sector for certain decision-making units.

Keywords: performance indicators, DEA method, production efficiency, efficiency analysis, case study

INTRODUCTION

The primary objective of every business is profit; therefore, it is logical that manufacturing companies continuously seek ways to reduce costs and increase earnings. All companies striving to improve profitability generally focus on two directions: producing a greater quantity of high-quality products and services without increasing costs, or improving efficiency and consequently employee productivity without the need to hire additional staff. The path toward improving company efficiency begins with an in-depth analysis of current operations. Internal measures, such as monitoring return on investment or analyzing profit margin trends, can help a company determine where its strengths and weaknesses lie in terms of achieving more efficient operations.

Company efficiency is the ratio between outputs (products/services) and inputs (labor, capital, materials), measuring how effectively a company utilizes resources to generate profit [1]. Among other aspects, business efficiency refers to reducing waste, simplifying processes, and maximizing output per unit of cost or time. Key metrics include inventory turnover, labor productivity, and operating margins, which are often improved through automation, better processes, and employee training.

Inefficient business processes cannot be viewed merely as wasted time; they may also burden company profitability, hinder the company's ability to satisfy consumer demand, and make it more difficult for employees to perform their tasks. Without proper management, small undetected issues may develop into serious problems which, in the worst-case scenario, can jeopardize the entire business operation.

Efficient companies maximize the use of their resources, transforming labor, materials, and capital into products and services that generate profit for the company. On the other hand, inefficient companies lack organization, which may slow down operations, cause losses of time and money, and negatively affect profitability. Efficiency is achieved through the proper identification and analysis of business performance indicators and through strategic actions based on such analysis.

Performance management is the process of ensuring that a set of activities and business results effectively and efficiently fulfills the objectives of an organization [2]. Depending on the level of management and planning, the focus may be placed on the performance of the organization, department, employee, or on the processes applied in carrying out specific tasks.

The measurement of the relative efficiency of business units (*DMUs*) can be conducted in several ways, and in this paper the DEA (*Data Envelopment Analysis*) method was used for this purpose. DEA is a non-parametric linear programming method in which similar inputs are used to produce similar outputs [3]. The DEA Method calculates the exact amounts of excess resources spent or lack of achieved results, which allows decision makers to define precise goals for optimization. Within the DEA approach, organizational units are defined as Decision-Making Units (DMUs). Efficiency, as one of the key business parameters, is measured as the relationship between achieved outputs and the inputs required for their realization. The advantage of this method lies in the fact that, in comparative efficiency analysis, it takes into account all relevant inputs and outputs regardless of the technology used for their transformation. This method identifies best practices (the efficiency frontier), enabling the comparison of efficient units, the identification of inefficient DMUs, and the establishment of targets for business improvement.

EFFICIENCY INDICATORS AND THE MEASUREMENT OF BUSINESS EFFICIENCY

Performance Indicators

There are various definitions of performance, and the definition itself differs from author to author; however, this concept most commonly refers to performance, achieved results, or accomplishments. Thus, the Oxford English Dictionary defines performance as a particular achievement, execution, implementation, or elaboration of something that has been done, that is, how well or poorly something functions [4]. Performance is also defined as the act or process of carrying out a task, action, etc., considering that the verb *perform* means to work or function well or poorly. Throughout the literature, scholars continuously emphasize that there is no standardized

or unique definition of performance, usually stating that it is a multidimensional concept. Regardless of this fact, Samsonova, after analyzing numerous definitions from authors from different regions, concluded that all definitions of performance measurement share one common characteristic: they are connected with two terms – effectiveness and efficiency. Effectiveness is viewed as an indicator of the degree to which objectives are achieved, while efficiency is an indicator of the resources consumed in order to achieve the targeted level of goal attainment [5].

Performance indicators are used in relation to concepts for which direct measurement is not always easily observable, despite continuous monitoring of developments that should lead toward the desired objective. Given this fact, performance indicators were designed as combined relevant quantified values that can be monitored over a certain period of time in order to obtain, as a final result, a partial metric of a particular action. Performance indicators can also be used for reporting functionality by measuring profitability within the commercial sector.

Since they relate to performance, that is, to the results of a process, performance indicators have always been important. The literature commonly states that the roots of performance management date back as far as 221 AD [6]. The importance of performance is linked to performance management, which was initially associated with the evaluation of individual performance. However, in the nineteenth century, during the Industrial Revolution and the introduction of mass industrial production, the focus shifted toward the management of organizational performance, which in most cases refers to operational efficiency and productivity.

Performance Management (PM) refers to the process of planning, monitoring, and improving the performance of individuals, teams, and organizations. Armstrong and Baron define performance management as a strategic and integrated approach intended to achieve sustainable organizational success by improving the performance of employees and enhancing the skills and capabilities of teams and individual contributors [7]. This process includes identifying performance objectives, measuring results, providing feedback, and managing performance development and improvement. It is a continuous and systematic process of improving organizational effectiveness by aligning employee performance with strategic business objectives. Instead of a single annual review, effective performance management involves continuous dialogue, goal setting, feedback, and development. Performance management focuses on how to achieve organizational goals through effective and efficient performance.

Since the management of performance indicators has proven to be productive, this business concept has become increasingly popular in modern times, meaning that companies recognize the need to measure and monitor their performance in order to make higher-quality decisions and improve their operations. Numerous studies testify to the popularity of these indicators. As stated by Ramić and Šabanić, research has shown that more than 90% of the world's most successful companies apply some form of key performance indicators in their operations [8].

When it comes to the production process and its improvement, there is a large number of performance measures and performance indicators that can be measured and monitored. Performance indicators represent a set of data collected through continuous monitoring of specific production activities, processes, or systems. Essentially, these indicators are highly important measures that monitor functioning, supervision, and control, that is, the overall management of activities, processes, and the system as a whole [9]. All performance indicators have both qualitative and quantitative functions, which need to be analyzed periodically, that is, checked to determine whether previously established objectives are being monitored and achieved. As the number of indicators measured for a particular performance increases, Atanasov states that the structure and complexity of measurement also increase; therefore, it is necessary to ensure that each indicator fulfills its intended purpose [10].

With regard to the number and structure of performance indicators that should be used in the production process within a company, they are not clearly defined and therefore vary from case to case depending on the purpose and intended use of the performance indicators. The most important aspect is that each performance indicator, that is, its value, can be compared with the values of performance indicators from similar companies, as well as with benchmark values. Therefore,

performance indicators are not particularly meaningful unless there is a defined objective toward which their value should strive.

Performance indicators are most commonly classified into one of four interconnected categories [6] (Savić, Martić, & Popović, 2022): (1) basic indicators; (2) derived indicators; (3) sets of indicators; and (4) performance measurement systems. Basic indicators are usually generated directly from databases and are synonymous with performance measures. For example, in manufacturing this may refer to the number of products produced, while in the sales sector it may refer to the number of products sold within a certain time interval. On the other hand, derived indicators represent a combination of two or more basic indicators (aggregation). Examples of derived indicators include productivity and technical efficiency as the ratio between outputs and inputs, or efficiency as the relationship between actual and benchmark values. A set of indicators is selected so as to represent and regulate a particular area or business process, while process management and coordination are carried out within the performance measurement system, which occupies the highest level in the hierarchy. Finally, the performance measurement system is responsible for coordinating indicators across different processes and functions, as well as aligning indicators from the strategic to the operational level [6].

According to Franceschini, most performance indicators can be associated with one of the following three types [11]: a) effectiveness – process characteristics indicating the extent to which process outputs correspond to requirements (whether the appropriate processes are being carried out); b) efficiency – process characteristics indicating the extent to which a process provides the required output with minimal resource costs (whether processes are carried out properly); c) customer focus – the extent to which customers/clients value the delivered performance.

On the other hand, certain authors [12] defined five basic criteria that performance indicators should satisfy: they should be precise and accurate, easy to understand, timely, action-oriented, and their implementation should not require costs that would represent a major burden for the company. Despite the fact that many performance measures satisfy these criteria, companies should not approach business process measurement merely for the sake of measuring something. On the contrary, based on established strategic goals, managers should focus on the most important (key) performance indicators, namely those that truly monitor output quality, process efficiency, and customer satisfaction. If there are too many performance measures, focus may be lost, resulting in unnecessary expenditure of time and various resources, especially financial ones [13].

By using performance indicators, companies can analyze the achieved progress in implementing strategic and operational goals through the framework provided by these indicators. Performance indicators also provide highly important insight into various aspects not only of production but also of the company's overall operations, enabling managers and all stakeholders to monitor progress and make timely and high-quality decisions based on such information. From all of the above, it is clear that selecting the best performance indicators is not easy, meaning that defining the criteria and selecting the performance indicators themselves represent a crucial step in measuring system performance.

Business Efficiency and Efficiency Indicators

Modern global economic reality is such that companies, in order to survive in the market, must possess the ability to efficiently manage their own resources and authorities and adapt to a constantly changing environment. This means that the management of a company must accurately assess the situation and anticipate market changes, because high-quality forecasting enables efficient development and the achievement of a certain competitive advantage. In accordance with such a way of thinking, companies in the new global economy are forced either to create projects adaptable to the environment or to seek business ideas that are ahead of the market and have a chance of survival. This requires operational flexibility and the ability to adapt or demonstrate creativity in business operations, which are elements that directly affect economic business efficiency. Under conditions of a changing environment, as Drucker states, companies seek methods that would guarantee them competitive advantage and development [14]. As a key

element of human and entrepreneurial development, serving self-fulfillment, the survival capability of modern society, and the degree of achievement of objectives, efficiency emerges as a central concept. Business efficiency is considered a factor affecting company competitiveness and represents the extent to which a company achieves its objectives [15].

According to most authors, efficiency consists of two basic components: technical efficiency, which reflects the ability to achieve maximum output from a set of inputs, and allocative efficiency, which reflects the ability to use inputs in optimal proportions considering their prices and production technology [16]. On the other hand, Trivedi defines business efficiency as the degree to which a company rationally allocates its limited resources in order to achieve predetermined goals, taking into account the limitations of the internal and external environment [17]. This means that business efficiency represents the ability to maximize results (revenues, products, services) while minimizing investments (time, effort, costs). More efficient operations affect profitability and long-term sustainability through process simplification, automation of repetitive tasks, and optimization of resource allocation. Consequently, business efficiency is one of the main indicators of the business success of every company, from which financial results, market positioning, and effects on customer satisfaction and engagement derive. It represents the result of the synergistic influence of many internal factors inherent to the company, as well as external mechanisms and conditions existing in the environment, thereby creating opportunities for development, benefit realization, and profit generation [18].

As the relationship between operational results (products/services) and invested resources (time, capital, labor), business efficiency also signifies the maximization of obtained value while minimizing waste and costs. This is achieved through process optimization, improvement of existing technologies or implementation of new technologies, and reduction of resource consumption in order to improve profitability.

Business efficiency directly affects profitability, growth, and sustainability because companies that continuously work on simplifying their processes can respond much faster to market changes, efficiently scale operations, and strategically allocate resources. Improving efficiency results in cost savings, better decision-making, and increased productivity, positioning the business toward long-term success.

Considering that the market economy, on the one hand, creates specific operational (managerial) conditions enabling companies to achieve their business objectives, while on the other hand imposing requirements that companies must fulfill in order to ensure the relative sustainability of their existence, it becomes clear how important business efficiency truly is. Based on the above, it is evident that one of the main business objectives is to improve operational efficiency; therefore, every step in this direction should begin with identifying the obstacles that slow down better business performance. Business efficiency can be achieved in several ways, although each of these approaches faces certain obstacles. One of the most common obstacles to improving operational efficiency is inherited operational processes. Namely, many companies believe that their growth and efficiency are directly linked to outdated processes. For example, there are still companies that rely on manual inventory recording and order processing. Such an approach not only results in significant time loss but also leads to frequent errors, such as overproduction or incorrect deliveries, which affect customer satisfaction and increase operational costs. It is clear that transitioning to an automated inventory management system could dramatically improve efficiency and, regardless of software acquisition costs, would prove to be an extremely profitable investment within a relatively short period of time.

Manual data entry, report generation, or invoice tracking have proven not only highly inefficient in modern business operations but also demotivating for employees. Such tasks are monotonous and reduce employee motivation and, consequently, productivity. Another issue related to business efficiency is poor and inefficient communication between departments, which creates fertile ground for confusion. For example, a sales department within a company may be unaware of changes in inventory, or a marketing team may launch a campaign without coordination with other departments. The lack of clear expectations, scattered information, and the

absence of smooth communication channels create delays, costly mistakes, and a poor work environment. In order to improve the business efficiency of a company, especially its production segment, it is often necessary to innovate existing business processes in order to achieve competitiveness. Any innovation process may encounter resistance from certain structures opposed to change. This type of resistance to change is not always malicious and often stems from fear of the unknown. It should be understood, as practice has shown, particularly in increasingly dynamic markets, that adherence to outdated methods hinders the implementation of solutions that could improve operational efficiency. Attitudes such as "we have always done it this way" block the adoption of new technologies, process optimization, and adaptation to constantly changing markets. Namely, in a dynamic business environment, flexibility represents the key to survival [19].

When it comes to business efficiency, another significant issue is the inadequate use of data. As important as it is to possess or obtain all necessary data, it is equally important to know how to use it properly. There are many companies that collect information in various ways and possess large amounts of data, yet lack the tools or expertise necessary to extract the information they currently need. The absence of an effective data analysis system prevents decision-making teams from identifying patterns, accurately predicting trends, and optimizing their strategies. In short, in the information age in which we live, knowledge and possession of information represent power and provide competitive advantage, provided that they are used properly and in a timely manner.

Measurement of Business Efficiency

The measurement of productivity and efficiency has always been and will continue to be of vital importance in a competitive business environment characterized by limited resources. The principles of the modern market and increasingly strong competition force companies to utilize all available resources in the most efficient manner possible. For this reason, performance and efficiency measurement and analysis represent important management tools that help companies determine the relationship between generated outputs and the inputs used, in order to improve their operations. Considering that performance indicators in manufacturing are key tools for measuring efficiency, productivity, and quality, and that they enable managers to make data-driven decisions, their significance is undeniable. The most important performance indicators in manufacturing include equipment efficiency, process time, product quality, and resource utilization. However, they are not easy to define, and even when developed, they may fail to indicate whether an organization operates on its production frontier, that is, efficiently.

In practice, various input and output indicators are used to create an efficiency index as their ratio, while the specific choice depends on the context in which efficiency is measured. For example, "for measuring economic efficiency, which relates to resource optimization, indicators such as the quantity of sold goods and production costs are used with the aim of achieving the highest possible output" [6].

Efficiency represents the ratio between two indicators, outputs and inputs, and it is easiest to determine in organizations that use only one input (costs, engaged resources, etc.) to produce one output (earnings, profit, revenue, etc.), according to the simple formula [6]:

$$Efficiency = \frac{input}{output} \qquad (1)$$

The above definition can easily be extended, particularly in situations where there are multiple homogeneous inputs and outputs expressed in the same value units, which can easily be reduced to a single input or output. Overall or production efficiency consists of two basic components: (1) technical efficiency and (2) allocative efficiency. Technical efficiency is viewed as the ability of a company to avoid or reduce production losses, that is, to produce as much output

as possible using a given quantity of inputs, or to produce the required quantity of output using the minimum amount of available resources. In the analysis of this type of efficiency, emphasis may be placed either on increasing outputs or reducing inputs. On the other hand, allocative efficiency refers to the ability of the observed entity to optimally combine inputs and outputs.

A highly important factor of technical efficiency is the so-called efficiency frontier, which represents a graphical presentation of the maximum production volume (output) that an economy or company can achieve using available resources (labor, capital, raw materials) and technology. There are several methods for obtaining the efficiency frontier curve based on input data, usually in the form of a function $y = f(x)$. If the analytical form of this function were known, measuring business efficiency would be simple. However, since in practice its form is generally unknown because only data on achieved output levels Y for certain inputs X are available for a number of similar organizations, parametric and non-parametric approaches are most commonly used in practice for evaluating the efficiency frontier.

The parametric approach is more frequently used for efficiency measurement. This approach requires imposing an analytical form of the function (regression equation or production function) that defines the relationship between independent and dependent variables [6]. In the parametric approach, the estimation of production function parameters is usually performed using regression analysis or linear programming, depending on how random influences are defined. On the other hand, the non-parametric approach is most commonly based on the so-called Farrell efficiency measure, according to which the efficiency frontier is formed by the best-performing units in the sample, while the remaining units are compared against that frontier. Farrell's efficiency measure represents the basis for measuring technical and allocative efficiency of production units (Data Envelopment Analysis – DEA) and was developed as a response to the inadequacy of partial indicators (productivity, economy) that cannot adequately encompass complex systems with multiple inputs and outputs.

DEA Method

The DEA method, is commonly described as the most successful and most widely used non-parametric method applied in efficiency analysis, performance measurement, and performance analytics. It is a data-based method for measuring the efficiency of complex entities that use diverse inputs to generate diverse outputs [6].

Using this method, which is based on linear programming, the relative productivity of decision-making units (DMUs) that use similar inputs to produce similar outputs is assessed, and deviations of less productive units are measured. In addition to this method, the parametric method known as Stochastic Frontier Analysis – SFA is also frequently used for efficiency measurement. Both approaches are based on comparing current performance with optimal performance located on the efficiency frontier [20].

Practice has shown that when there are multiple input and output indicators heterogeneous in nature (financial, technical, technological, environmental, social, etc.) and expressed in different units of measurement, it is extremely difficult to perform an accurate performance assessment. In such cases, it is not possible to draw high-quality conclusions regarding the level of success based solely on partial efficiency indicators that measure the effectiveness of individual resources, because their values generally move in opposite directions (minimization of undesirable indicators or resource values and maximization of desirable indicators, i.e., outputs). Farrell partially solved this problem by enabling the inclusion of multiple inputs and a single output, or multiple outputs and a single input, in the analysis. However, the simultaneous inclusion of multiple heterogeneous inputs in the process of generating multiple heterogeneous outputs was not possible within his analysis [6]. Farrell's significance lies in the fact that his work served as the basis for the efficiency analysis method known as Data Envelopment Analysis (DEA).

The DEA method was developed in 1978 by Abraham Charnes, William W. Cooper, and Edward Rhodes, and based on the initials of their surnames the basic CCR model was created. To this day, it remains the best-known DEA model and is based on Farrell's work on productivity

measurement. In 1984, these authors expanded their original method by introducing the BBC model, which enabled efficiency analysis under variable returns to scale. A further extension was introduced in 1985 by Banker, Charnes, and Cooper through the BCC model, and later that same year the method was further expanded by defining efficiency through the so-called Pareto-Koopmans efficiency (a production plan – a set of inputs and outputs –Pareto-Koopmans is efficient if it is impossible to increase the production of any output or reduce the consumption of any input without simultaneously reducing the production of another output or increasing the consumption of another input) [21]. Basic DEA models were designed to assess technical efficiency, while modified DEA models were developed for evaluating multiple parameters: scale, costs, price efficiency, and changes in productivity and efficiency over time.

The development of the DEA method was primarily motivated by the need to evaluate the operational efficiency of non-profit organizations such as schools, hospitals, kindergartens, etc., that is, to assess the efficiency of related organizational units where the presence of a large number of inputs and outputs makes comparability difficult. Within the DEA approach, organizational units are defined as Decision-Making Units (DMUs). Efficiency, as one of the key business parameters, is measured as the relationship between achieved outputs and the inputs required for their realization. The advantage of this method lies in the fact that, in comparative efficiency analysis, it takes into account all relevant inputs and outputs regardless of the technology used for their transformation. In this way, a modified form of Equation (1) for efficiency measurement is obtained, in which all inputs and outputs are included:

$$Efficiency = \frac{Sum\ of\ inputs}{Sum\ of\ outputs} \qquad (2)$$

that is,

$$h_k = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad (3)$$

where:

h_k – relative efficiency of the k-th DMU
m – number of inputs
v_i – weight coefficient for input i
s – number of outputs
u_r – weight coefficient for output r

The basic problems in calculating efficiency using Equation (3) are scaling problems, that is, the comparability of data located within different value ranges, and weighting, that is, determining the relative importance of inputs and outputs by assigning weight coefficients. The scaling problem was solved through data standardization, by limiting the value of the efficiency index to a scale from 0 to 1, meaning that h_k is assigned a weight coefficient greater than 0 and less than 1. In this way, the need for data scaling prior to DEA implementation is eliminated.

The problem of assigning weight coefficients was solved in such a way that Charnes, Cooper, and Rhodes proposed that efficiency analysis does not require a single objective set of weights. Instead, each decision-making unit (DMU) can define its own set of weight coefficients with the objective of maximizing its own efficiency, provided that the types of inputs and outputs, as well as the minimum allowable weight values, are predefined [22].

In order for the DEA method to be applied, several fundamental assumptions must be satisfied: (1) for every decision-making unit (DMU) whose efficiency is to be evaluated, available data on input and output values must exist; (2) all inputs must have positive values; (3) all data necessary for decision-making must be included in the efficiency analysis; (4) the efficiency index should reflect input minimization and output maximization; (5) input and output measurement units do not have to be homogeneous [3].

Based on the analyzed input and output data, the DEA method evaluates whether a particular decision-making unit is relatively efficient or not. The efficiency frontier, representing the maximum level of output achievable for given input values, is formed as an envelope surrounding the set of observed entities. Decision-making units located on this frontier are considered efficient, while the remaining units are assessed as relatively inefficient. If it is possible for a decision-making unit to produce a greater output using the same inputs, or to produce the same output using fewer inputs, then that unit is considered inefficient [23].

ANALYSIS OF PRODUCTION SECTOR EFFICIENCY USING THE DEA METHOD – A CASE STUDY

Basic Information about the VENDOM Company

The company Vendom d.o.o. Laktasi was established in 2003. The company operates in the field of metal industry manufacturing for both domestic and international markets, with a particular focus on foreign markets (the EU and South America), primarily producing various types of waste disposal containers. At the beginning of 2026, the company employed more than 200 workers and generated annual revenues exceeding EUR 10 million, making Vendom d.o.o. Laktasi one of the largest exporters in the metal sector in Bosnia and Herzegovina.

The company's most important competitive advantages are short delivery times, high reliability, and quality. Compared to competitors, Vendom products stand out due to their design, innovation, and quality. Additional advantages of cooperation with this company include its ability to respond to specific customer requirements, product customization, assembly services, servicing, and product maintenance.

The company's wide product portfolio ranges from industrial and residential fences, smaller steel structures up to 100 t, to highly demanding industrial structures with load capacities of up to 1,000 t. Particularly notable within the Vendom product range are underground and above-ground waste management systems, as well as cranes for container emptying. In addition to the above-mentioned products, the company also offers structures, fences, steel molds, underground and above-ground waste containers, cranes, steel structures for construction facilities, and various steel products manufactured according to customer requirements or based on solutions developed by the company's engineers.

In addition to its own products, the company also offers services on both domestic and international markets, including laser, plasma, and gas sheet metal cutting, sheet metal bending, sheet punching, welding, sandblasting, powder coating, assembly, repair and reconstruction, conceptual solutions, product design, and product development according to customer requirements or based on the company's own conceptual designs. Annually, the company produces more than 2,500 above-ground and underground waste containers, 50 cranes, 100,000 various metal products, and more than 30 steel structures.

Efficiency Analysis of the Production Sector

As previously stated, the company Vendom is engaged in the sale of finished products within the metal industry. Therefore, production utilization and total added value were analyzed for 13 products: containers (1–3), cranes (4–6), antenna towers (7–8), pallets (9–10), and cables (11–13), which in this case study represent the Decision-Making Units (DMUs).

Considering the objective of the analysis and the availability of data, the following were used as input variables: material costs – MC, labor costs – LC, and the number of work operations –

WO, while total added value – TAV (sales price minus product costs) was used as the output variable.

Prior to selecting the input and output variables, data preprocessing was performed, and the inputs and outputs were created as derived indicators through the aggregation of corresponding basic cost or revenue indicators. The positivity check confirmed that all variables had positive values.

Table 1. Input and Output Variables in Euros

DMU	Product	Input Variables			Output Variables
		Material Costs (€)	Labor Costs (€)	Number of Work Operations	TAV (€)
1	**Container Size A**	548.02	230.76	10	1,083.35
2	**Container Size B**	499.87	210.32	10	999.26
3	**Container Size C**	601.43	240.28	11	1,114.74
4	**Crane Height A**	13,675.75	4,724.24	12	24,301.33
5	**Crane Height B**	12,987.46	4,654.23	12	24,134.85
6	**Crane Height C**	15,007.66	5,004.32	13	24,653.47
7	**Antenna Tower A**	21,139.56	3,521.00	16	31,873.65
8	**Antenna Tower B**	22,456.38	3,909.43	17	35,506.66
9	**Pallet A**	34.31	38.73	11	98.52
10	**Pallet B**	39.63	40.23	11	99.81
11	**Cable Length A**	320.17	309.29	11	1,232.67
12	**Cable Length B**	333.78	321.67	11	1,244.77
13	**Cable Length C**	363.29	341.52	11	1,233.75

The results of the correlation analysis conducted on the entire dataset are presented in Table 2. The values of the correlation coefficients indicate that there is a positive correlation between each input and output variable, meaning that the isotonicity assumption has not been violated. An increase in inputs leads to an increase in outputs. Although the correlation coefficients are relatively high in most cases, there is no complete correlation between any two indicators, which means that there are no redundant data. The lowest correlation was observed between the number of work operations and labor costs.

The efficiency index was calculated using the following weighting factors for the input variables, based on the positive operational practices of the Vendom company: $a = 0.8$; $b = 0.8$; $c = 0.6$. In accordance with the selected weighting factors and following the DEA analysis, the most efficient DMUs were identified as Antenna Tower B (8), Pallet A (9), and Cable Length A (11), as shown in Table 3.

Table 2. Correlation Analysis

Correlation Analysis	Material Costs	Labor Costs	Number of Work Operations	Total Added Value
Material Costs	1			
Labor Costs	0.901	1		
Number of Work Operations	0.908	0.660	1	
Total Added Value	0.996	0.931	0.876	1

Table 3. Efficiency Index

	MC	LC	WO	TAV	EI	Normalized EI Value	Relative Efficiency h
1	548.02	230.76	10	1,083.35	1.72	0.71	0.72
2	499.87	210.32	10	999.26	1.74	0.72	0.77
3	601.43	240.28	11	1,114.74	1.64	0.68	0.74
4	13,675.75	4,724.24	12	24,301.33	1.65	0.68	0.76
5	12,987.46	4,654.23	12	24,134.85	1.71	0.71	0.81
6	15,007.66	5,004.32	13	24,653.47	1.54	0.64	0.70
7	21,139.56	3,521.00	16	31,873.65	1.61	0.67	0.98
8	22,456.38	3,909.43	17	35,506.66	1.68	0.70	1.00
9	34.31	38.73	11	98.52	1.51	0.63	1.00
10	39.63	40.23	11	99.81	1.42	0.59	0.82
11	320.17	309.29	11	1,232.67	2.42	1.00	1.00
12	333.78	321.67	11	1,244.77	2.34	0.97	0.95
13	363.29	341.52	11	1,233.75	2.16	0.89	0.76

The results of the conducted DEA analysis indicate the actual state of efficiency within the production sector of the Vendom company, which operates in the field of metal industry manufacturing. The research showed that the efficiency of the DMUs ranges from 70% to 100%. Three DMUs – Antenna Tower B, Pallet A, and Cable Length A (8, 9, and 11) proved to be fully efficient, while two additional units – Antenna Tower A (7) and Cable Length B (12) demonstrated very high efficiency levels, reaching approximately 95% efficiency.

The least efficient units were Crane Height C (6) and Container Size A (1), whose efficiency levels were approximately 70%. Nevertheless, it is certainly possible to improve the efficiency of these units and thereby enhance the overall efficiency of the production sector. This is because the DEA method enables the creation of target values for the observed inputs and outputs, on the basis of which improved business efficiency can be achieved.

The obtained results also indicate the need for continuous monitoring and evaluation of production sector efficiency. The average relative efficiency of the observed DMUs amounted to approximately 85%, which represents a satisfactory level that can certainly be further improved.

Continuous monitoring and comparison of results over specific time intervals will enable the identification of key production-related problems and indicate which DMUs should be influenced through the reduction or increase of inputs or outputs in order to achieve better overall business results for the company.

CONCLUSION

The efficiency of business processes, especially within the production sector, represents a highly important component of the operations of every company. Inefficient business processes not only result in the loss of valuable time and make it more difficult for employees to perform their tasks, but can also significantly affect company profitability and hinder the company's ability to satisfy consumer demand.

Market competition requires companies to utilize their resources to the maximum extent and, more importantly, to use them efficiently by transforming labor, materials, and capital into products and services that generate profit for the company. Improved efficiency is achieved through the proper identification and analysis of business performance indicators and through strategic actions based on such analysis.

Efficiency represents the ratio between two indicators, outputs to inputs, and it is easiest to determine in organizations that use only one input (costs, engaged resources, etc.) to produce one output (earnings, profit, revenue, etc.).

The DEA method, is commonly considered the most successful and most widely used non-parametric method applied in efficiency analysis, performance measurement, and many other analytical tasks. It is a data-based method for measuring the efficiency of complex entities that use diverse inputs to generate diverse outputs. By means of this method, which is based on linear programming, the relative productivity of decision-making units (DMUs) that use similar inputs to produce similar outputs is assessed, and deviations of less productive units are measured.

Using the DEA method, an efficiency index was created, which enabled an objective ranking of the observed units.

The weighting factors of the input variables needed to calculate the Efficiency Index are assigned with reference to the positive practice of the Vendom company.

The results of the DEA analysis indicated the actual state of efficiency in the production sector at the company Vendom.

The research conducted in this paper showed that the efficiency of individual DMUs within the analyzed company ranges between 70% and 100%. Three DMUs (Antenna Tower B, Pallet A, and Cable Length A) proved to be fully efficient, while two additional units (Antenna Tower A and Cable Length B) demonstrated very high efficiency levels of approximately 95%. The least efficient units were Crane Height C and Container Size A, whose efficiency levels barely exceeded 70%. It was concluded that the efficiency of these units could be improved by acting upon the input and output components (through the application of target values), particularly in the case of Crane Height C through the reduction of labor costs, and in the case of Container Size A through increasing the product price, which would improve the efficiency of the production sector within the Vendom company.

The limitations of this research are related to the inability to observe certain additional input-output indicators, since, based on the available company data, it was not possible to systematize such indicators for all DMUs analyzed in this study. Considering that the company's management has recognized the importance of monitoring input-output indicators for improving production efficiency, future research on this topic, which has already been planned, will certainly include additional DMUs as well as new input-output indicators. It is expected that the obtained results will indicate further directions for action aimed at additionally improving production efficiency.

DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

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