OVERALL LABOR EFFECTIVENESS AS A TOOL FOR MEASURING PERFORMANCE IN A GIVEN COMPANY

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Abstract

To remain competitive, a company needs to increase the productivity of its production equipment, which can be monitored using the Overall Equipment Effectiveness indicator. The article aims to describe the modification of the Overall Equipment Effectiveness indicator into the indicator of Overall Labor Effectiveness in a given company. The advantage of this indicator is that it monitors not only the use of the employee's labor pool but also the actual costs spent on the product. In addition to that, the impact of the introduction of this indicator on the economic performance of a given company is analyzed. To do so, four periods before and four periods after the introduction of the Overall Labor Effectiveness indicator were analyzed using four selected financial ratios. The value of the Overall Labor Effectiveness indicator is currently in the range of excellent values, i.e. the firm uses production time very efficiently. The results of the analyzed financial ratios show that the introduction of the Overall Labor Effectiveness indicator increased the performance of the given company.

Keywords

Competitiveness; Financial ratios; Losses; Productivity; Performance indicator.

Introduction

Current trends in financial management aim to analyze the company's performance using the shareholder value creation indicator. This concept is based on value management theory. This is a consistent application of the criterion of maximizing the net present value that the company is able to create for its owners, i.e., maximizing shareholder value.

Over several decades, a wide range of measures has been developed to express a company's performance. The changes in usage of various measures reflect the development of views on measuring company performance from profit margins and return on invested capital to modern concepts based on value management and shareholder value creation. Performance measurement systems containing benchmarks are proposed to support the company's strategy.

Many companies in the manufacturing industry both abroad and in the Czech Republic are nowadays using the Overall Equipment Effectiveness indicator (OEE) to measure and manage their performance. This indicator has been modified into several so-called derived indicators based on various requirements in the efficiency assessment. One of the derived indicators is the Overall Labor Effectiveness (OLE). However, the application of the Overall Labor Effectiveness indicator is not very common in practice. In addition to that, this indicator is not of great interest to scientists; its usage was mentioned e.g., by Braglia et al. [1] or Deepak et al. [2]. For this reason, the authors of this article have focused on the issue of calculating this indicator and its application in the selected company. Furthermore, the influence of the OLE indicator's introduction on the company's performance was also analyzed.

1 Literature Research

Parmenter [3] states that many companies use wrong measures that are incorrectly called key performance indicators (KPIs). He recommends rule 10/80/10, i.e., there are ten key results indicators, 80 performance indicators, and ten key performance indicators in the company. Other authors, such as Kaplan and Norton [4], also addressed the number of indicators and recommended a maximum of 20 key performance indicators. Remeš and Goswami [5] list five basic business performance measures categories (types). However, very few companies monitor their correct key performance indicators. The reason is that very few companies, responsible persons, consultants, etc., know what a key performance indicator is.

One method of measuring performance that companies widely use is "Overall Equipment Effectiveness (OEE)" [6]. Overall equipment efficiency (OEE) is an indicator of production equipment efficiency, which compares the efficiency of individual production equipment and entire production lines. In the 1960s, it was compiled by Seiichi Nakajima from the Nippon Denso company for the Japanese Institute of Plant Maintenance. This is a crucial indicator that helps to detect the hidden capacity of production machines, i.e., to identify losses. Utilization of hidden capacities helps increase productivity, reduce product prices, secure competitive advantage, and ultimately increase the company's operating profit. The OEE indicator aims to minimize wastage, increase output and quality measures, and thus improve efficiency [7]. The proper using of the OEE indicator requires using appropriate tools enabling real-time management of equipment [8]. This is consistent with the findings of Yazdi et al. [9], who studied the relationship between the OEE indicator and individual aspects of industry 4.0. The usage of the OEE indicators was further studied e.g., by Li et al. [10], Di Luozzo et al. [11], or Aminuddin et al. [12].

2 Research Objectives

The article's main aim is to measure the introduction of the indicator of Overall Labor Effectiveness on the performance in a given company. The modification is called Overall Labor Effectiveness, and it is designed to analyze capacity losses caused by human capital-related downtime in the form of absenteeism or shift changes. The main reason for introducing this indicator is to monitor the use of the labor force (worker), i.e., its productivity. This indicator is relatively new; there are only a few research articles focused on this topic. The advantage of this indicator is that it monitors not only the use of the employee's labor pool but also the actual costs spent on the product. Furthermore, the article analyzes the influence of the introduction of the OLE indicator in a given company operating in the automotive industry in the Czech Republic. Therefore, with the help of selected ratios, the economic performance of a given company in four periods before and four periods after the introduction of OLE has been analyzed.

3 Methodology

Based on literature research, the Overall Equipment Effectiveness indicator was characterized. Furthermore, the primary three subcomponents of the OEE indicator were defined. Subsequently, the method of its calculation was described. Additionally, three online consultations using Google Meet (April, August, and November 2021) were conducted with the CFO of the analyzed company. The analyzed company is a subsidiary of a multinational company, and its main business is the production of one single component for the automotive industry. The company carries out only the final assembly of a given component, and at the same time, each manufactured component undergoes a final inspection. The analyzed company is classified as a large enterprise according to all the measures (net assets, turnover,

and employees). In these consultations, questions were directed to the following basic information:

- what reasons led the company to modify the OEE indicator to an OLE indicator,
- where the company has drawn experience and information for the introduction of the OLE indicator,
- how the company has set up the calculation of the modified OLE indicator and how it has verified the accuracy of its predictive power,
- how the indicator was communicated to the staff,
- how the trade union and the employees reacted to the new indicator,
- how long it took to introduce the indicator in the enterprise,
- what the enterprise sees as the benefits of introducing the OLE indicator.

Based on the information mentioned above, the formula for calculating the OLE indicator is presented, including the characteristics of its subcomponents. The calculation of the OLE indicator value is based on specific values reported by the company, which had to be adjusted by a single coefficient not to disclose specific information.

To assess the impact of the introduction of the OLE indicator on the financial results, data obtained from the Magnus Web database was used, namely from the basic financial statements, including other supplementary data. Four periods before and four periods after the introduction of the OLE were analyzed. For this analysis, the following four indicators were chosen to compare the impact of OLE: Net Profit per Employee, Earnings before Interest and Taxes per employee, Return on Assets, and Return on Sales.

4 Overall Equipment Effectiveness Indicator

The OEE value is vital information for companies that continuously want to improve and streamline their production processes. This indicator comprises several components (parameters) that can be evaluated separately and thus influence the overall effectiveness. OEE helps maximize the company's assets to the availability of time (Availability) in producing output (Performance) with the best product quality (Quality) [13].

The overall effectiveness of the equipment is an effective tool for identifying bottlenecks. It can be integrated with other continuous improvement tools and techniques [14]. It is used in improvement programs such as downtime management (DTM), lean manufacturing, Six Sigma, or Kaizen. Hence, the indicator of overall equipment effectiveness (OEE) is suitable for reducing the identified losses and thus improving both performance and quality in production, leading to an increase in the company's operating profit.

The OEE indicator captures information on the availability, performance of production facilities, and production quality. The resulting values of these three sub-indicators are affected by certain losses. Sohal et al. [15] identified the following six main losses related to availability, performance, and quality:

- poor productivity and lost yield due to poor quality,
- set-up and adjustment for product mix change,
- production losses when temporary malfunctions occur,
- differences in equipment design speed and actual operating speed,
- defects caused by malfunctioning equipment, and
- start up and yield losses at the early stage of production.

Jonsson and Lesshammar [16] classified these losses into the three following groups: downtime losses (availability), speed losses (performance), and quality losses. Each group consists of two subgroups that characterize the losses in more detail, see Table 1.

Tab. 1: *Losses affecting the resulting values of individual factors of OEE*

Category of losses	Factor of OEE	Type (subgroup) of losses	Examples of losses
Downtime	Availability	Breakdown losses	Equipment failure Damage to the instrument Unscheduled breaks Waiting for work to be assigned Errors in logistics in the delivery of input material
		Set-up and adjustment losses	Heating processes Tool change
Speed loss	Performance	Idle losses (machine does not work)	Temporary disorder Change in production Defective material delivered
		Speed reduction	Difference between construction speed and operating speed Poor technical condition of the machine Unskilled labor
Quality	Quality	Machine run-up	Heating processes Failure to comply with standards
		Quality defects	Failure to comply with technological procedures Defective input material (scrap production) Machine failure Unclear task assignment Employee errors

Source: Own elaboration based on [17] and [18]

4.1 The Calculation of the Overall Equipment Effectiveness Indicator

The OEE consists of three sub-components: machine usage (availability), machine performance, and quality level of production. The calculated values of these individual components are multiplied together to obtain the resulting OEE value. Its value is given as a percentage of the utilization of the standardized capacity of the equipment. Simply put, it determines the percentage of production time that is genuinely productive. If the OEE indicator is equal to 100%, it means 100% quality (good products only), 100% performance (as fast as possible), and 100% availability (no downtime). If the value of the OEE is greater than 85%, it usually represents excellent values, meaning that the company works very efficiently. However, the resulting percentage varies according to the type of production - while in batch or piece production, the percentage is, in principle, smaller, in mass and highly automated production, it is between 90 and 100% [8]. The OEE indicator is calculated using formula 1.

$$\text{OEE} = \text{Availability rate} \times \text{Performance efficiency} \times \text{Quality rate} \times (100\%) \quad (1)$$

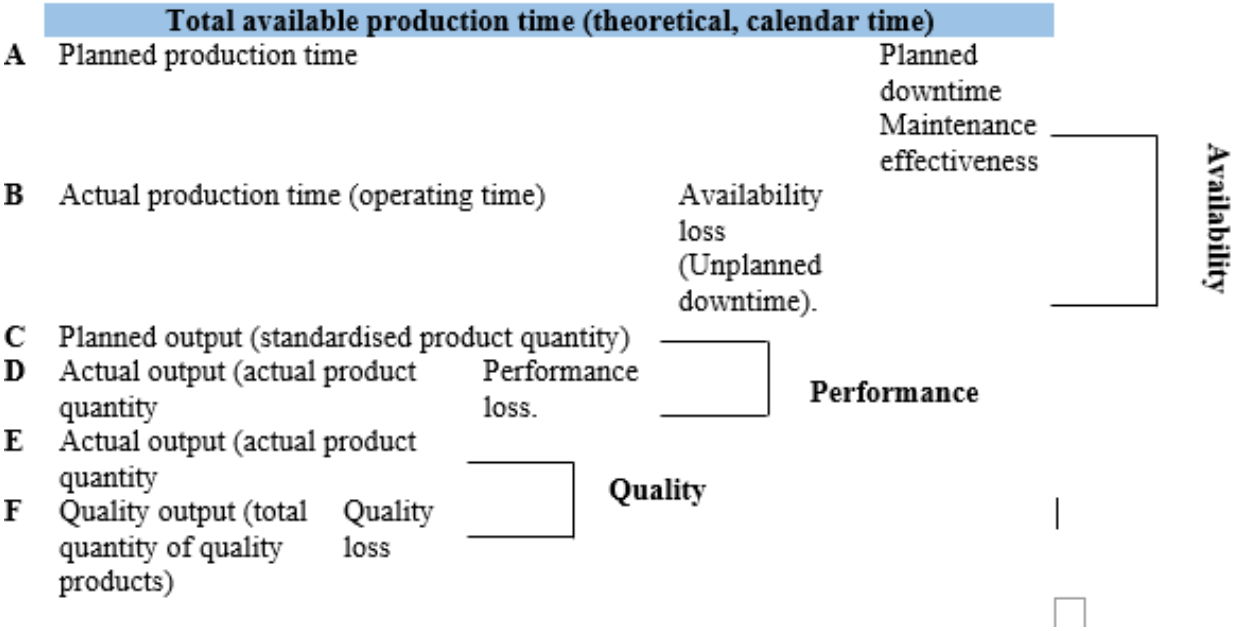
The exact definition of OEE differs between applications and authors. Table 2 shows the two approaches applied by Nakajima [19], the original author of OEE, and De Groote [20].

Tab. 2: *The calculation of the OEE indicator*

Indicator	Nakajima [19]	De Groote [20]
Availability (A)	$\frac{\text{Loading time} - \text{downtime}}{\text{Loading time}}$	$\frac{\text{Planned production time} - \text{Unplanned downtime}}{\text{Planned production time}}$
Performance (P)	$\frac{\text{Ideal cycle time} \times \text{output}}{\text{Operating time}}$	$\frac{\text{Actual amount of production}}{\text{Planned amount of production}}$
Quality (Q)	$\frac{\text{Input} - \text{volume of quality defects}}{\text{Input}}$	$\frac{\text{Actual amount of production} - \text{nonaccepted amount}}{\text{Actual amount}}$
OEE	(A) × (P) × (Q)	(A) × (P) × (Q)

Source: Own elaboration based on [19] and [20]

Figure 1 shows the input values that are used to calculate the individual components of the OEE indicator. The total available time represents a period of 7 days per week and 24 hours per day. There are periods when production is neither realized nor scheduled within this time frame. This is planned downtime, which includes days off work and public holidays falling on a working day.



Source: Own elaboration based on [15]

Fig. 1: *Illustration of the main components of OEE*

In order to capture critical data and to examine how production contributes to overall company performance, it is vital to measure and understand how to quantify failures in the production process. Management experts commonly refer to OEE measurement as the best metric for identifying losses, advancing progress, and improving production equipment productivity. By measuring OEE, important information can be obtained on how to improve the production process systematically. Most manufacturing companies, even today, have an OEE score of about 60% and are more likely to encounter companies with OEE values below 45% than companies with OEE values above 85% [21].

Today, many companies in the field of industrial automation, not only abroad but also in the Czech Republic, deal with the measurement and evaluation of OEE, which offer consulting

services and specific software, applications, and entire systems for data collection, evaluation, and presentation.

4.2 Application of the OEE Principles to the Workforce in the Analyzed Company

Following the new requirements in the evaluation of effectiveness, so-called derived indicators have been developed, which are focused on either the equipment or the enterprise level. One of the most widely used indicators is the Total Equipment Effectiveness Performance (TEEP). The next derived indicator is Production Equipment Efficiency (PEE). Other derived indicators correspond to the specific requirements of particular industries (Overall Asset / Procedure Effectiveness – OAE, OPE). For expressing the efficiency of the whole enterprise, the Overall Factory Effectiveness (OFE) indicator is used [22].

The analyzed company has implemented its modification of the OEE indicator, namely the indicator of labor efficiency (OLE). In this modification, capacity losses, which in the case of OEE represent downtime, set-up, and adjustment, are replaced by human capital-related downtime in the form of absenteeism or shift changes. Similarly, capacity losses in the case of OEE are replaced by missing processes, lack of training, or staff working non-standard. The last part of the OEE indicator focuses on quality, which focuses on quality errors, the need for rework, or start-up errors. These quality-reducing factors are retained in the modification of the OEE to OLE in the case of quality error and need for rework. At the same time, the ramp-up error factor is modified to the non-compliance with processes factor. To calculate the Overall Labor Effectiveness, the analyzed company adjusted the calculation of the individual components as shown in formulas 2, 3, and 4.

$$\text{Availability} = \frac{\text{Productive time} + \text{External extra work}}{\text{Total production time}} \tag{2}$$

$$\text{Performance} = \frac{\text{Number of faultless products x standard time} + \text{External extra work}}{\text{Productive time} + \text{External extra work}} \tag{3}$$

$$\text{Quality} = 1 - \frac{\text{Scrapping costs}}{\text{Material costs}} \tag{4}$$

4.3 Process of Implementation of the OLE Indicator in the Analyzed Company

To succeed in a competitive market, the company consistently applies a customer-oriented management system. For this reason, it is constantly improving and enhancing its production processes and introducing indicators that will lead to improved production efficiency and quality. The key performance indicator in the analyzed company is modifying the OEE indicator to the OLE indicator.

When the company decided to monitor the OLE indicator, it first had to answer the question, “Why introduce and monitor this indicator?” Firstly, the company decided to use only one comprehensive indicator instead of a variety of indicators to measure and manage its performance. The customers put pressure on the company to keep the cost of the required products as low as possible. Therefore, it was necessary to start monitoring the use of individual employees’ work funds to avoid unnecessary downtime and achieve the highest possible labor productivity. The introduction of a single OLE indicator will lead to the determination of all employees’ bonuses. At the same time, it will increase the motivation of each employee. This will align with the goals of the company and its employees.

The second question was, “Where to get experience and information to implement the OLE indicator?” Selected employees completed training on the use of the OLE indicator, where they could discuss the issue and problems with the implementation of the indicator with

companies that already had the indicator in place or were implementing it. Finally, yet importantly, it was necessary to draw on the theoretical information provided in the literature or professional articles.

In the next step, it was necessary to ask, "How to set the calculation of the indicator and adapt it to the conditions of the company?" Several years ago, the company had data available for individual production lines and individual shifts. Based on this data, the company was able to determine a formula for calculating the OLE indicator and set appropriate goals. Subsequently, the calculation of the given indicator had been performed for several previous years, which showed that in some parameters the calculation was not accurate. The formula has been modified to provide relevant information based on these findings.

The input values for the calculation of Overall Labor Effectiveness (OLE) in the analyzed enterprise, which are presented in Table 3, were adjusted by a constant coefficient. Based on the given data, formulas 2, 3, and 4 were used to calculate individual components of the OLE indicator.

Tab. 3: *The calculation of Overall Labor Effectiveness*

Initial situation		**Shift time structure**	**Hours**
Shift length	8 hours	Productive time	130.0
Lunch break	30 minutes	Internal extra work	0.0
Number of workers in the line	20 workers	External extra work	6.5
Number of handlers in the line	1 worker	Waiting for material	0.0
Standard time	125 minutes per 100 pieces	Manipulation	7.5
		Machine repairs	6.0
Shift recording		Production changes	6.0
Number of production changes	3 times per shift	Training	0.0
Time to change production	6 minutes	Sampling	10.0
Technical downtime	18 minutes	Total production time	166.0
Production of samples	30 minutes		
Additional material inspection	1 worker		
Number of faultless products	6,000 pieces		
Material costs	900,000 CZK		
Scrapping costs	3,750 CZK		

Source: Own

$$\text{Avalability} = \frac{130.0+6.5}{166.0} \times 100 = 82.23\%.$$

$$\text{Performance} = \frac{[(6{,}000 \times 125):100]:60+ 6.5}{130.0+6.5} \times 100 = \frac{125+6.5}{136.5} \times 100 = \frac{131.5}{136.5} \times 100 = 96.34\%.$$

$$\text{Quality} = 1 - \frac{3{,}750}{900.000} \times 100 = (1 - 0.00417) \times 100 = 0.99583 \times 100 = 99.583\%.$$

OLE = (0.8637 x 0.9634 x 0.99583) x 100 = 82.86%.

The resulting value of the OLE indicator corresponds to a good performance but it should be increased to over 85%, which is the mark of excellent companies.

4.4 Impact of the Introduction of the OLE Indicator on the Economic Results of the Analyzed Company

Since the company does not wish to disclose specific OLE data, data from the Balance Sheet, Profit and Loss Statement, and other supplementary data gathered from the MagnusWeb database were used to assess the impact of the introduction of OLE in the analyzed company. The average values of selected financial ratios calculated for the monitored indicators before and after the introduction of the OLE indicator are presented in Table 4. The years 2020 and 2021 were not included in the analysis period as the economic results are already affected by the impact of the Covid-19 pandemic.

Tab. 4: *Average values of selected indicators before and after the introduction of the OLE indicator*

Ratio	**Average values of selected ratios before introducing the OLE indicator**	
	2012 – 2015	**2016 – 2019**
ROA (in %)	7.20	8.63
ROS (in %)	3.22	3.80
EAT per one full-time employee (in thousands CZK)	154.35	208.88
EBIT per one full-time employee (in thousands CZK)	209.08	228.20

Source: Own elaboration based on the data from MagnusWeb database

The net profit per employee in the first year after the OLE indicator was introduced declined. In the following years, the EAT ratio gradually increased, and the values in each year significantly exceeded the values before introducing the OLE indicator. After introducing the OLE indicator the average EAT per employee increased by approximately 50,000 CZK. The same development was also observed in the EBIT per employee. After introducing the OLE indicator the average EBIT per converted employee increased by approximately 20,000 CZK.

Next, the development of two profitability ratios (ROA and ROS) was analyzed. The inputs used to calculate the ROA ratio were net profit and total assets. The introduction of the OLE indicator led to an increase in the Return on Assets ratio. After the introduction of OLE, the average ROA ratio increased by 1.4%. A similar development was observed for the ROS indicator. After introducing the OLE indicator the average ROS ratio increased by 0.6%.

Based on the results, it can be concluded that the introduction of the OLE indicator led to an increase in the company's performance. From the results of the monitored ratios, it can be concluded that the enterprise uses production time productively and, therefore, minimizes time losses. The correct identification of time losses has probably led to increased profits, which is reflected in an increase in profitability values. Data on product scrap rates were not provided, so it is not possible to determine whether there has been a reduction in scrap rates.

5 Discussion

The advantage of this indicator for the company was that its introduction did not entail significant interventions in management. The indicator was introduced in the company within six months. This brief period of time was due to the fact that the company had the necessary data from several years back, on which it could verify the design, functionality, and informative power of the OLE indicator. In terms of the achieved value of the OLE indicator presented in Table 3, the result ranks the analyzed company among the companies that work very efficiently, i.e. that they use production time effectively. The introduction of the OLE

indicator also led to an increase in the financial performance indicators, as shown in Table 4. The obtained results relate only to the analyzed company, and for this reason, these results cannot be generalized.

Generally speaking, the OEE and derived indicators cover all the causes of time loss that can be considered in a given situation. In addition to that, these indicators can be expressed in monetary units almost immediately. There is no need to wait for the publication of financial statements to calculate the loss. In terms of quality, the issue of the production of defective products entered the subconscious mind of employees, which led to its reduction. However, it is necessary to realize that the production of a defective product may not be caused only in the production process but may be caused by other influences, such as the defective material supplied, etc. [1]. When evaluating the resulting values of the OLE indicator, it is always necessary to consider the field of business and the type of production. Furthermore, the OLE indicator monitors the use of the employee's labor pool and the actual costs spent on the product [2]. Other authors, such as Bonci et al., suggest introducing a new LEAN-ROLE indicator that can identify the employees' contribution to the customer's value [23].

Conclusion

The OLE indicator must be taken as a concept covering everything that happens in the production process. The reason for the introduction of this indicator was to monitor the use of the labor force (worker), i.e., his productivity. It is also crucial for employees to be given one indicator that they can monitor themselves, which has also led to a modification of the remuneration system. This indicator affects the bonuses of all employees based on their work performance. Employees see (understand) that this is a fair distribution of bonuses and therefore accept this indicator. The introduction of the OLE indicator has led to an increase in employee awareness of the importance of production.

The authors would like to continue with their research by preparing a questionnaire survey, which would focus on companies with the same field of business as the analyzed company. The results of the research would provide interesting information, since the OEE, OLE indicators or other modifications of the OEE indicator and their impact on financial performance are not a very common topic of research articles.

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CELKOVÁ EFEKTIVITA PRÁCE JAKO NÁSTROJ PRO MĚŘENÍ VÝKONNOSTI V DANÉM PODNIKU

Pro udržení konkurenceschopnosti je velmi důležité, aby společnost zvyšovala produktivitu svých výrobních zařízení, což lze sledovat pomocí ukazatele Celkové efektivity zařízení. Článek pojednává o modifikaci ukazatele Celkové efektivity zařízení na ukazatel Celkové efektivity práce v rámci daného podniku. Výhodou tohoto ukazatele je, že monitoruje nejenom využití pracovního fondu zaměstnance, ale i skutečné náklady výroby daného produktu. Dále je analyzován vliv zavedení tohoto ukazatele na ekonomickou výkonnost daného podniku. Za tímto účelem byly analyzovány 4 vybrané ukazatele ve 4 letech před zavedením ukazatele Celkové efektivity práce a ve 4 letech po jeho zavedení. Hodnota ukazatele Celkové efektivity práce v současnosti nabývá hodnot, které lze označit za výborné, a proto lze konstatovat, že podnik využívá výrobní čas efektivně. Výsledky analyzovaných finančních ukazatelů dokazují, že zavedením ukazatele Celkové efektivity práce došlo ke zvýšení výkonnosti daného podniku.

DIE ALLGEMEINE ARBEITSEFFIZIENZ ALS INSTRUMENT ZUR BEWERTUNG DER LEISTUNG EINES BESTIMMTEN UNTERNEHMENS

Um wettbewerbsfähig zu bleiben, ist es für ein Unternehmen sehr wichtig, die Produktivität seiner Produktionsanlagen zu erhöhen, was mit dem Indikator der Gesamteffizienz der Ausrüstung überwacht werden kann. In diesem Artikel wird die Modifizierung des Indikators der Gesamteffizienz der Ausrüstung Indikators in den Indikator der Gesamtarbeitseffektivität in einem Unternehmen erörtert. Der Vorteil dieses Indikators besteht darin, dass er nicht nur die Nutzung des Arbeitskräftepools der Arbeitnehmer überwacht, sondern auch die tatsächlichen Kosten für die Herstellung des Produkts. Außerdem werden die Auswirkungen der Einführung dieses Indikators auf die wirtschaftliche Leistung des Unternehmens analysiert. Zu diesem Zweck wurden vier Perioden vor und vier Perioden nach der Einführung des Indikators der Gesamtarbeitseffektivität anhand von vier ausgewählten Finanzkennzahlen analysiert. Der Wert des Indikators liegt derzeit im Bereich dessen, was als exzellente Werte bezeichnet wird, d.h. das Unternehmen nutzt die Produktionszeit sehr effizient. Die Ergebnisse der analysierten Finanzindikatoren zeigen, dass die Einführung des Indikators der Gesamtarbeitseffizienz die Leistung des Unternehmens erhöht hat.

CAŁKOWITA EFEKTYWNOŚĆ PRACY JAKO NARZĘDZIE POMIARU WYNIKÓW W DANYM PRZEDSIĘBIORSTWIE

Aby zachować konkurencyjność, przedsiębiorstwo musi zwiększyć produktywność urządzeń produkcyjnych, co można monitorować za pomocą wskaźnika Ogólnej Efektywności Wyposażenia. Celem artykułu jest opisanie modyfikacji wskaźnika Ogólnej Efektywności Wyposażenia na wskaźnik Ogólnej Efektywności Pracy w danym przedsiębiorstwie. Zaletą tego wskaźnika jest to, że monitoruje on nie tylko wykorzystanie puli pracy pracownika, ale również rzeczywiste koszty wydatkowane na produkt. Dodatkowo analizowany jest wpływ wprowadzenia tego wskaźnika na wyniki ekonomiczne danego przedsiębiorstwa. W tym celu przeanalizowano cztery okresy przed i cztery okresy po wprowadzeniu wskaźnika Ogólnej Efektywności Pracy, wykorzystując cztery wybrane wskaźniki finansowe. Wartość wskaźnika Ogólnej Efektywności Pracy znajduje się obecnie w przedziale wartości doskonałych, czyli firma bardzo efektywnie wykorzystuje czas produkcji. Wyniki analizowanych wskaźników finansowych wskazują, że wprowadzenie wskaźnika ogólnej efektywności pracy zwiększyło wydajność danego przedsiębiorstwa.