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MEASURING THE EFFICIENCY OF THE TRANSPORT PROCESS IN DISTRIBUTION CENTRES OF A TRADING COMPANY

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Abstract: Distribution centres are complex business systems in which various interconnected processes are realized. The efficiency of distribution centres depends on a number of indicators that stipulate the way processes and activities in a system function. By monitoring the performance indicators and their deviation from defined target values, the need to respond and apply appropriate corrective actions can be designated. This paper analyzes the efficiency of the transport process of a trading company in Serbia. For efficiency analysis, the CCR DEA model was used, which integrates different performance indicators into a single efficiency measure. The analysis of the transport process was conducted through two studies. The first study analyzed the efficiency of 93 drivers based on the following variables: working hours of drivers, route duration, fuel consumption, distance travelled, transport errors, number of routes per driver, vehicle utilization time and number of deliveries. The second study analyzed the efficiency of the fleets of four distribution centres based on the following variables: number of drivers, number of vehicles, working hours of drivers, route duration, distance travelled, transport errors, air pollutant emissions and number of deliveries. Output and input oriented models were made in the first study. According to the obtained results of both models, the average efficiency of the driver was 82%, which means that each driver can achieve a higher output, i.e. input by 18%. In the second study, an output-oriented model was made and according to the obtained results, the average efficiency of fleets was 95%. The results of both studies indicate the possibility of applying certain corrective measures and improving the organization of work in the transport process. The developed models can be applied to real systems and assist managers in making decisions in order to improve operational efficiency.

Keywords: efficiency, transport, CCR DEA model, logistics.

1. Introduction

Distribution centres (DCs) need to carry out their logistics activities and operations efficiently due to dynamic changes on the market. Monitoring and analysis of various performance indicators make it possible to assess the efficiency and sustainability of companies' operations, which strive to improve performance by monitoring the current situation and applying corrective actions. Companies aim to optimize their supply in order to achieve the highest possible profit and competitiveness on the market. In order to achieve this goal, indicators have to be monitored in all logistics processes, from

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production and storage, through distribution and transport to the sale of products in retail. This paper analyzes the efficiency of the transport process in DCs of a trading company operating in Serbia.

The aim of this paper is to analyze the efficiency of the transport process by applying Data Envelopment Analysis (DEA) and to propose corrective measures for inefficient units. The analysis of the transport process was conducted through two studies using the OSDEA-GUI-v0.2 (Virtos, 2021) software tool. The first study refers to the analysis of driver efficiency, and the second to the analysis of fleet efficiency in the period from August to November 2020. The paper analyzes the efficiency of 93 drivers for the representative month of October and the efficiency of four fleets for DCs companies in Novi Sad, Belgrade, Cacak and Nis.

The paper is organized into four chapters. The first chapter provides an overview of the literature on the application of the DEA method for evaluating the efficiency of different systems. The second chapter describes the transport process efficiency problems that companies face. The third chapter describes the DEA model used to measure the efficiency of drivers and fleets. The fourth chapter describes two case studies of the trading company's transport process efficiency. A description of the business system is given, input and output quantities for the DEA model and the results of the model as well as corrective measures to improve the efficiency of inefficient units.

2. Literature Review

As road transport is the most used type of transport and a large consumer of energy, the analysis of the efficiency of the transport process is very important. Transport is a subsystem of logistics that has the highest energy consumption and its method affects the operation of DCs. Many authors use the DEA method in their research as a tool to analyze process efficiency. Andrejić and Kilibarda (2012) developed a model for evaluating the operational efficiency of transport processes of 13 fleets for DCs located in Serbia. Nguyen *et al.* (2015) used the extended DEA model (bootstrapped DEA) to evaluate the efficiency of 43 Vietnamese ports and compared the results with the results of the standard DEA method and stochastic frontier analysis (SFA). Andrejić *et al.* (2013a) analyzed the efficiency of a DCs trading company by applying the Principal Component Analysis (PCA-DEA) model due to greater discriminatory power than the standard DEA approach. The authors state that the biggest problem is the choice of relevant indicators from a large set of indicators that describe the work of DCs. Furthermore, Andrejić (2011) applied the DEA model for measuring warehouse efficiency and proposed a model with defined quantities that describe the functioning of warehouses in the best possible way.

Markovits-Somogyi and Bokor (2014) applied the DEA-PC (Pairwise Comparison) method to assess the logistics efficiency of European countries. Omrani and Keshavarz (2016) used the standard DEA model and the network DEA model to assess the efficiency of the supply chain of international shipping companies in Iran in the period 2008-2011.

Large amounts of energy needed in transport at the world level and higher energy prices lead to the very important issue of energy conservation. There has been an increasing number of papers in which the authors dealt with this issue and used the DEA method for analysis. Azadi *et al.* (2014) proposed two DEA approaches for setting performance targets in green supply chain management for transport service providers. Andrejić *et al.* (2013b) proposed a model for assessing energy efficiency of several modes of transport in Serbia from 2001 to 2010. Using the DEA model, Ji *et al.* (2016) assessed the environmental indicator of a sustainable supply chain of a transport company that manufactures air conditioners in China. Zhou *et al.* (2014) applied the DEA model to consider unwanted outputs for energy efficiency of transportation in China. The goal was to maximize potential energy savings in the transport sector in the period 2003-2009. Ratković *et al.* (2011) proposed a model for measuring the efficiency of 35 medical institutions in the process of collecting and treating medical waste based on the DEA approach.

3. Transport Process

This part of the paper describes the observed transport process, i.e. possible problems and reasons for their occurrence in the transport process that companies face. The growing demand for goods on the market creates new challenges for companies that are expected to respond quickly and in the best way to the demands of the customer. Adequate management of transport and distribution of goods increases mobility and accessibility which can lead to possible savings (Rodrigue, 2020). Distribution of goods means all processes and activities that are necessary to deliver goods from producers to consumers.

Transport is an indispensable element in the process of goods distribution that achieves a spatial transformation between the producer and the final consumer. The transport process generates high costs, high energy consumption and high toxic gases emission, which is why it is important to monitor and analyze performance so that transport efficiency can be at a higher level. When planning and organizing the transport system, adequate decisions should be made regarding the transport capacity, choice of transport means, routing, maximum vehicle utilization, etc. (Andrejić and Kilibarda, 2017). By making adequate decisions, significant savings and greater efficiency of the transport system can be achieved. Otherwise, the reason for relatively inefficient transport systems may be a larger number of vehicles than the real requirements and needs for transport, which creates high fixed costs, inadequate choice of vehicle type, poor routing, etc.

Road transport is the most dominant transport in the distribution of goods and its importance is growing. The reasons for this are the possibility of door-to-door delivery of goods, smaller order sizes, increased frequency, punctuality of delivery, etc. In the transport subsystem, more and more attention is paid to the development of sustainable transport, due to the adverse effects on the environment. Trucks are considered to be one of the main sources of air pollution problems, traffic jams, noise and harmful gas emissions (Andrejić and Kilibarda, 2018). One of the key challenges for logistics is the reliability of goods distribution in urban areas. Reasons for inefficient urban distribution of goods may be underdeveloped adequate traffic infrastructure, increased number of vehicles, unforeseen traffic events, delivery of small quantities of goods, etc. (Rodrigue, 2020). In the worst case, delayed delivery of goods can lead to production termination. Such problems are difficult to predict and to find alternative solutions. In addition to such problems, there are other risks (Andrejić and Kilibarda, 2018): traffic accidents, vehicle breakdowns, damage to goods in transport, inadequate packaging, etc.

4. DEA Model for Measuring Efficiency

There are various quantitative and qualitative methods and techniques in literature for measuring performance at different organizational levels of a company. The DEA method is a mathematical programming technique that enables mutual comparison of systems, i.e. determines whether each decision making unit (DMU), based on input and output data, is relatively efficient compared to other units that are part of the analysis (Andrejić and Kilibarda, 2017).

The standard CCR (Charnes, Cooper and Rhodes) DEA approach was used for this research, which is the basis to all other extended DEA models. There are two orientation directions in the DEA method: input-oriented and output-oriented, and there are also non-oriented models. The goal with output-oriented models is to maximize output at a defined input level, and an inefficient unit becomes efficient by increasing its outputs. In an input-oriented model, the goal is to minimize the input required to produce the required amount of output, and an inefficient unit can become efficient by reducing its inputs until its outputs change. In the non-oriented model, improvements in outputs and inputs are calculated simultaneously to make the unit efficient (Savić, 2016). In this paper, a CCR DEA model with constant yield on volume (input and output oriented) was used and its formulation is as follows (Charnes *et al.,* 1978):

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

with the following restrictions:

$$\frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \le 1, \qquad k = 1, 2, \dots, n$$

$$u_r \ge 0, \qquad r = 1, 2, \dots, s$$

$$v_i \ge 0, \qquad i = 1, 2, \dots, m$$

where:

h_k – relative efficiency k-th DMU,
X_{ik} – the i-th input value for k-th DMU ($x_{ik} > 0, i = 1,2, \dots, m, k = 1,2, \dots, n$)
Y_{rk} – the r-th output value for k-th DMU ($y_{rk} > 0, r = 1,2, \dots, s, k = 1,2, \dots, n$)
n – number of DMU to be compared,
m – input number,
s – output number,
u_r – weight variable for output r,
v_i – weight variable for input i.

The relative efficiency h_k for k-th DMU is the ratio of the weight sum of the output (virtual output) and the weight sum of the input (virtual input). The CCR model with a constant return to scale, known in the literature as the ratio model, calculates the overall technical efficiency, which includes pure technical efficiency and efficiency as a consequence of different business volumes. The goal function in the model tends to maximize the value of h_k in such a way that each DMU assigns values to control variables u_r and v_i so that they would be represented better. The application of constant return to scale (CRS) increases the value of engaged inputs, which results in a proportional increase in the outputs, depending on the orientation of the model. According to the set restrictions, the efficiency will be $0 < h_k \leq 1$. The weight variables u_r and v_i show the degree of importance of each input and output so that the DMU is as efficient as possible (Charnes *et al.,* 1978; Savić, 2016).

5. Case studies of Transport Process Efficiency in a Trading Company

This paper describes two case studies for researching the efficiency of the transport process in a trading company in Serbia. The research was realized using the CCR DEA model. Data were obtained from the management of the observed company and no consistency of data collection was observed.

5.1. System Description

The observed company has been operating in Serbia for more than 20 years in the field of trade in electrical and electronic devices. The company, in addition to traditional sales, also provides online sales that affect the entire supply chain and logistics processes. The company has its own transport and storage resources, but in certain situations it also hires logistics providers to implement these processes. In the case studies, only the company's own resources were observed. The company owns four DCs located in Novi Sad, Belgrade, Cacak and Nis. The spatial distribution of DCs is shown in Figure 1.

Fig. 1.
Spatial Distribution of DCs

Until 2020, the entire logistics processes of the trading company were managed by engaged logistics providers (outsourcing), and now it is in the process of developing its own logistics (insourcing). Internal innovations and development of logistics processes in the company aim to increase efficiency and cost-effectiveness by using its own resources that reduce costs, price of goods, improve quality and increase profits. Figure 2 shows a flow chart of distribution activities, in order to better understand the business logic and processes in the company.

The first step in the process of distributing goods is to form an order. It starts with the customer searching for the product on the company's e-platform and checking the availability of the product. If the product is not in stock, the buyer is directed to further search for a similar product, and if the product is available and the buyer decides to buy online, the next step is to choose the delivery location (retail facility or home delivery). The customer orders after defining the delivery location and selecting the payment method (payment by payment card via the Internet, cash on delivery or payment via invoice).

The second step is to receive the purchase order. The company receives the order from the customer through BBIS software, which is a software solution for running a trade business. The company collects orders and once a day performs a cut off time of orders received in the system.

The third step is order processing. After collecting orders, the dispatcher plans the routes of the delivery vehicle for the following day in the Pantheon software program and prepares the necessary documents for the distribution of goods.

The fourth step is the order picking of goods and includes the activities performed by the orderpicker: order picking, disposal of goods in shipping zone and packaging of goods. After the process of packing, inspection and control of goods and documents, the goods are deposited on the transshipment front.

The fifth step is the shipment of the order and it consists of two activities: loading into the vehicle realized by the worker in the loading zone and transport realized by the driver. During the delivery process, the driver announces the delivery to the customer about an hour earlier.

The sixth step is the delivery of the order. Delivery is successfully realized by delivering all products to the buyer/retailer and signing the document, after which the vehicle is returned to the DC. Also, it may happen that the delivery is not realized, and the reasons for returning the shipment can be: delay of delivery, damage of goods or cancellation of delivery. In all three cases, the goods are returned to the warehouse and the documents are handed over to the worker responsible for receiving the returned deliveries. After registering the documents, the delivery cycle ends.

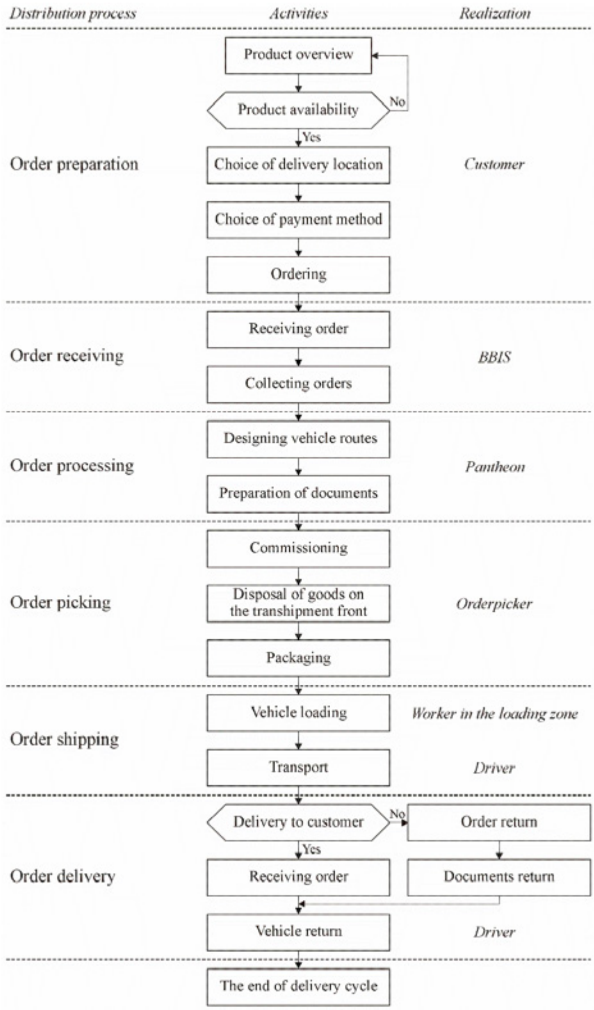

Fig. 2.
Distribution Activity Flow Diagram

5.2. Description of Inputs and Outputs in the DEA Model

The key data monitored in logistics relate to system structure, labour productivity, economic efficiency and quality. The structure of the system describes the logistics system according to its area, capacity and available resources. Data on labour productivity are a measure of the effectiveness and efficiency of the system, organization method and realization of work. Economic efficiency is reflected in the ratio of costs and revenues, while data on quality describe the level of fulfilment of set goals and performance (Gleissner and Femerling, 2013). Groups of indicators can be found in literatures that are used to evaluate the efficiency of the DCs subsystem. In this paper, individual indicators from the following groups of indicators for the transport subsystem are observed: resource indicators, energy indicators, operational indicators, utilization indicators and qualitative indicators (Andrejić and Kilibarda, 2017). Indicators can be input or output from the system.

In the first study, each DMU represents one driver. Indicators used for the analysis were: driver's working hours, route duration, fuel consumption, distance travelled, transport errors, number of routes per driver, vehicle time utilization and number of deliveries. Three input and five output variables were used in this study. The indicators that represent the input to the DEA model were: the driver's working hours, route duration and fuel consumption, while the remaining indicators represent the output from the model. The inversion (1/value) was applied to the output value of the transport error, in order to reduce this negative quantity, and not to increase it in the target values in the output-oriented model. The aim of the first study was to evaluate the efficiency of each driver, in order to control their work and identify possible deviations after which corrective measures would be proposed.

In the second study, each DMU represented one DC for the observed month. The indicators used were: number of drivers, number of vehicles, working hours of the driver, duration of the route, distance travelled, transport errors, emissions of harmful gases and number of deliveries. Two input and six output variables were used in this study. The indicators that represent the input to the DEA model were the number of vehicles and drivers, and the other indicators were the output from the model. Inversion (1/value) was also applied to the output values of the transport error and emission of harmful gases as in the first study. Tier 1 emission factor was used to calculate the emission of harmful gases, i.e. the amount of CO2 emitted (Papić *et al.,* 2010). The emission factor for diesel vehicles was 3.14 [kg CO_2/kg fuel]. The aim of the second study was to use the DEA model to evaluate the efficiency of each DC for the period from August to November, which would give the trading company managers an insight into the productivity of the transport process in DCs.

Resource indicators, in the conducted studies, refer to the number of drivers and the number of vehicles that are necessary for the successful distribution of products. The number of vehicles describes the size of the fleets of the DCs of the trading company. Energy indicators are indicators of fuel consumption and emissions of harmful gases (CO_2). Increasing attention is being paid to energy and environmental indicators in logistics, as energy costs are a significant part of total costs in DCs. The group of operational indicators includes the following indicators: driver's working hours, route duration, distance travelled, number of deliveries and number of routes per driver. These operational indicators are important for monitoring the productivity of transport in the process goods distribution. The working hour indicator is the total operating time of the driver, and the route duration indicator refers only to the time the driver spent driving. The number of unloadings represents the total number of deliveries of goods to the retail facilities of the trading company and to the home addresses of customers. The utilization indicator refers to the percentage of time utilization of the vehicle in the distribution process and represents the ratio of time spent driving and the total number of working hours of the driver. Qualitative indicators, in this case, refer to the monitoring of transport errors. The indicator of transport error is the number of failed deliveries, i.e. number of returned packages. In addition to this error, errors can be monitored that cause delivery delays, damage to goods, complete loss of goods, etc.

5.3. Results

The efficiency of logistics processes can be observed at different levels: strategic, tactical and operational (Andrejić and Kilibarda, 2017). This paper presents the results of measuring efficiency at the operational level for the transport process, i.e. for the efficiency of individual vehicles (first study) and fleet efficiency (second study) for four DCs of the observed trading company.

The first study analyzed driver efficiency in all DCs for the representative month of October 2020, when the total number of drivers was 93. In the model, each driver is an independent DMU. For all four DCs, the input and output quantities described in the previous part of the paper were observed. Due to the large number of drivers, the paper presents the input data for nine drivers (Table 1). In the first study, input and output oriented DEA models were applied which gave the same efficiency results. Depending on the orientation of the model, there are differences in the target values of the quantities that indicate the direction of change (decrease in input or increase in output) for the purpose of improvement.

Table 1

Input and Output Values for Measuring Driver Efficiency

DMU	Driver's working hours [h]	Route duration [h]	Fuel consumption [l]	Distance travelled [km]	Inversion value transport errors	Number of routes per driver	Vehicle time utilization [%]	Number of deliveries
I/O	I	I	I	O	O	O	O	O
Driver 1	237.65	184.06	452.34	4308	0.0345	30	0.77	326
Driver 2	223.8	181.11	486.36	4632	0.0196	31	0.80	523
Driver 3	197.25	145.93	420.63	3816	0.0244	32	0.73	418
...								
Driver 40	219.31	179.93	294.31	2803	0.0286	31	0.82	445
Driver 41	210.41	178.08	221.76	2112	0.0278	31	0.84	532
Driver 42	230.5	194.91	248.64	2368	0.0222	32	0.84	587
...								
Driver 91	201.96	179.5	446.14	4249	0.0714	31	0.88	383
Driver 92	217.58	212.41	606.37	5775	0	31	0.97	471
Driver 93	172.15	106.83	324.76	3093	0.0909	31	0.62	219
Average	194.40	147.40	400.39	3722	0.0570	31.10	0.75	289.13
St. Dev.	35.80	34.86	159.69	1425	0.1240	0.66	0.11	139.24
I – Input, O – Output								

Table 2 shows the results of driver efficiency. Out of a total of 93 drivers observed, 16 (17.2%) were efficient, while the remaining 77 drivers (82.8%) were technically inefficient. The average efficiency according to the CCR DEA output-oriented model was 82%, which indicates that each driver could achieve a higher output by 18%, i.e. a higher number of deliveries and routes and better time utilization of the vehicle for the same number of working hours. The input-oriented model has the same efficiency result as the output-oriented model. In that case, it can be concluded that the same number of deliveries and the number of routes can be realized with 18% less working hours of drivers. Depending on the manager's decisions, a smaller number of inputs or a larger number of outputs can be decided. In the output-oriented model, the goal is to increase the number of outputs with the same working hours (number of deliveries, number of routes and better utilization of vehicles), while in the input-oriented model the goal is to achieve the same output with less input (number of working hours).

Table 2

Driver Efficiency Results

DMU	Efficiency
Driver 1	0.67
Driver 2	0.99
Driver 3	0.97
...	
Driver 40	0.85
Driver 41	1
Driver 42	1
...	
Driver 91	0.89
Driver 92	1
Driver 93	0.76
Average Efficiency	0.82
Standard Deviation	0.14
Number of efficient DMU	16 (17%)

Table 2 shows that Driver 1 has the lowest efficiency and that, according to the output-oriented model, he can improve efficiency by increasing output by 33%, which means that with the same number of working hours he can realize 162 deliveries more per month (Driver 1 can be fully efficient if he realizes a total of 488 deliveries). In the specific case for Driver 1, the obtained weight variables (according to the output-oriented model) are: driver working hours $v_1 = 6.1 \cdot 10^{-3}$, route duration $v_2 = 2.8 \cdot 10^{-4}$, fuel consumption $v_3 = 1.6 \cdot 10^{-6}$, distance travelled $u_1 = 4.7 \cdot 10^{-2}$, vehicle time utilization $u_4 = 0.3$, number of deliveries $u_5 = 1.73 \cdot 10^{-3}$, while the variables for transport errors and the number of routes per driver are 0 (a value of 0 indicates that these values do not contribute to improvement). Observing the results of the input-oriented model, Driver 1 can realize the same number of deliveries with 33% less working hours in that month, which indicates that the organization of driver work could be improved. This further means that the driver can be efficient with 79 hours less work than the already realized number of working hours (237.65), which is 159 hours. The obtained weight variables for Driver 1 (according to input-oriented model) are: driver working hours $v_1 = 4.1 \cdot 10^{-3}$, route duration $v_2 = 1.9 \cdot 10^{-4}$, fuel consumption $v_3 = 1.1 \cdot 10^{-6}$, distance travelled $u_1 = 3.1 \cdot 10^{-2}$, vehicle time utilization $u_4 = 0.2$, number of deliveries $u_5 = 1.1 \cdot 10^{-3}$, while the variables for transport errors and the number of routes per driver are also 0 as for the output model. Drivers rated 1 are technically efficient and there is no need to improve their performance.

Based on the results of the first study, five driver efficiency classes were defined, which are shown in Figure 3. The greatest number of drivers (42) is in class 0.91-1, of which 16 are technically efficient. The next most numerous class is 0.71–0.8 which contains 22 drivers. The efficiency classes 0.61–0.7 and 0.81–0.9 have a similar number of units, while the 0.51–0.6 class contains the smallest number of drivers (4). Analysis of the results shows that no driver has an efficiency of less than 50% and that a large number of drivers could improve their efficiency. Depending on the work performance of the driver, i.e. the ratios of input and output variables differ in driver efficiency ratings. Drivers can be compared according to efficiency assessments and analysis of input data. For example, when comparing the first two drivers, it can be concluded why Driver 1 is 66% efficient and Driver 2 is 99% efficient. It can be noticed that Driver 2 with a smaller number of working hours achieved a higher number of unloadings and higher time utilization of the vehicle compared to Driver 1. A similar analysis can be applied to other drivers.

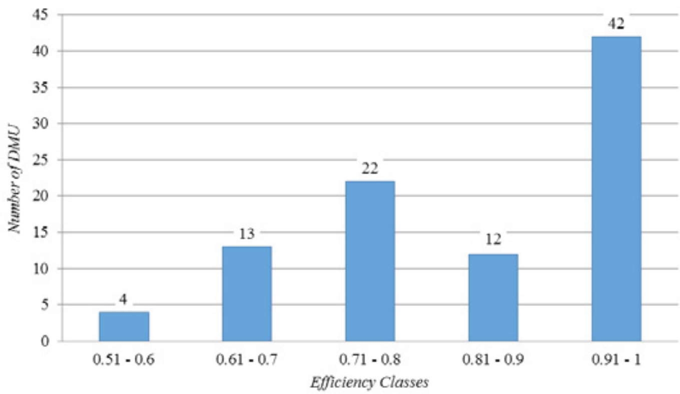

Fig. 3.
Driver Efficiency Classes

The second study analyzed the efficiency of fleets for all four DCs for the period August-November 2020. Each DC has a fleet that represents one DMU for each month, meaning there are a total of 16 DMUs. The first four DMUs refer to DC Novi Sad, the following four DMUs to DC Nis, then to DC Belgrade and the last four to DC Cacak. All vans have similar capacities, functioning system and diesel fuel drive. The model has two input sizes and six output sizes, which were described in the previous part of the paper. Table 3 shows the data for input and output quantities. An output-oriented model was used in this study, to assist managers to achieve greater system efficiency. In this study, greater efficiency is achieved by influencing the output rather than the input variables. Table 3 shows that the number of drivers changed from month to month in each DC, whereby DC Belgrade was prominent. DC Belgrade had a larger volume of work in the observed period and 13 more vehicles were purchased.

Table 3

Input and Output Quantities for Measuring Fleet Efficiency

DMU	Number of drivers	Number of vehicles	Working hours of the driver [h]	Duration of the route [h]	Distance travelled [km]	Inversion value transport errors	Inversion value emissions of harmful gases [1/kg CO_2*10^5]	Number of deliveries
I/O	I	I	O	O	O	O	O	O
DMU 1	12	9	1576.9	1110.9	38550	0.005	7.867	1967
DMU 2	13	9	2184.8	1590.7	41717	0.002	7.270	2804
DMU 3	12	9	2409.6	1859.2	52615	0.004	5.764	3757
DMU 4	11	9	2125.7	1715.0	50395	0.011	6.018	3693
DMU 5	11	9	1377.1	793.4	31744	0.002	9.554	1836
DMU 6	11	9	1564.5	1333.7	35655	0.001	8.506	1992
DMU 7	12	9	1851.1	1513.2	37096	0.002	8.176	2539
DMU 8	12	9	1928.7	1517.2	38391	0.005	7.900	2662
DMU 9	34	30	4440.7	1751.5	80738	0.024	3.756	6427
DMU 10	49	40	7696.6	5080.7	130380	0.001	2.326	12019
DMU 11	51	41	10249.2	7720.3	146361	0.001	2.072	18494
DMU 12	52	43	10564.7	8327.0	47999	0.001	6.319	19556
DMU 13	20	17	3401.5	1734.8	86935	0.002	3.488	2022
DMU 14	18	17	3545.1	2758.3	93147	0.001	3.256	2160
DMU 15	19	17	3575.2	2617.8	88764	0.001	3.416	2099
DMU 16	18	17	3296.8	2440.0	84386	0.001	3.594	2010
I – Input, O – Output								

Data on fleet efficiency are shown in Table 4. According to the results of the CCR DEA model, the average fleet efficiency is 95%, with 63% of fleets being efficient. The fleets can be divided into two groups. Ten DMUs belong to the group of efficient ones, while six DMUs belong to the group of inefficient ones. Given that it is an output-oriented model, DMU 9 (DC Belgrade, August) can become efficient and improve its business if it increases the output by 26%. This further means that DMU 9 must increase the number of deliveries by 26% with the same number of drivers and with two vehicles less, in order to become efficient (it must realize a total of 11,415 deliveries). The obtained weight variables for DMU 9 are: number of drivers $v_1 = 4 \cdot 10^{-2}$, errors in transport $u_4 = 41$, and other weight variables are 0. DMU 10 (DC Belgrade, September) can become efficient if it increases the output by 22%, which is 4189 more deliveries, namely, to realize a total of 16,208 deliveries. The obtained weight variables for DMU 10 are: number of drivers $v_1 = 3 \cdot 10^{-2}$, working hours of driver $u_1 = 1.2 \cdot 10^{-4}$, distance travelled $u_3 = 8.8 \cdot 10^{-8}$, and other weight variables are 0.

The last column in Table 4 shows the benchmarks, i.e. reference DMUs for inefficient DMUs and lambda weights.

Lambda weights represent the degree of importance for inefficient units that need to observe the efficient ones. The reference units for the observed DMU 1 are DMU 3, DMU 4 and DMU 5. For DMU 1, DMU 5 (lambda = 0.59) is more important than DMU 3 (lambda = 0.1) and DMU 4 (lambda = 0.31). For DMU 9, as the least efficient unit, the reference is DMU 4 with a weight variable of 3.09. In order to improve the efficiency of this unit, the number of deliveries should be increased by 4988, the number of errors reduced by 10, emissions reduced by 21,244 kg of CO2 and the number of vehicles reduced by 2. Other inefficient units could improve their efficiency in a similar way. Effective units could also be self-referential. In the group of efficient ones, DMU 3 stands out, which appears as a reference unit for five inefficient DMUs. In addition to this unit, DMU 4, DMU 5 and DMU 14 also stand out, which are reference units for two, one and three inefficient units.

Table 4

Fleet Efficiency Results

DMU	Efficiency	Benchmarks (Lambda weights)
DMU 1	0.97	DMU 3 (0.1), DMU 4 (0.31), DMU 5 (0.59)
DMU 2	1	DMU 2
DMU 3	1	5
DMU 4	1	2
DMU 5	1	1
DMU 6	1	DMU 6
DMU 7	1	DMU 7
DMU 8	1	DMU 8
DMU 9	0.74	DMU 4 (3.09)
DMU 10	0.78	DMU 3 (2.94), DMU 12 (0.26)
DMU 11	1	DMU 11
DMU 12	1	DMU 12
DMU 13	0.91	DMU 3 (0.81), DMU 14 (0.57)
DMU 14	1	3
DMU 15	0.95	DMU 3 (0.51), DMU 14 (0.72)
DMU 16	0.93	DMU 3 (0.23), DMU 14 (0.85)
Average Efficiency	0.95	
Standard Deviation	0.08	
Number of efficient DMU	10 (63%)	

The change in the efficiency of the four DCs for the time period from August to November 2020 is shown in Figure 4. Based on the graphical representation, three groups of DCs can be defined. The first group consists of DCs that were highly efficient in the observed period and whose efficiency rating was 1, namely DC Nis and DC Novi Sad. The second group, DC Cacak, whose efficiency was high, but varied in the range from 0.91 to 1. The third group was DC Belgrade, whose efficiency significantly improved from August (0.74) to November (1). The fact is that DCs of Novi Sad and Nis are smaller than DCs of Belgrade and Cacak. Taking into consideration their size and scope of work, the organization of business in larger DCs is more complex than in smaller ones.

The increase in efficiency for DC Belgrade in the observed period could be explained by better utilization of resources and higher work achieved in October and November due to the existence of special discounts in sales that affected the increase in the volume of work. This raises the question of whether there is a need for the same number of resources in the period without the existence of sale discounts. The answer to this question requires observing a longer period of time than was done in this study.

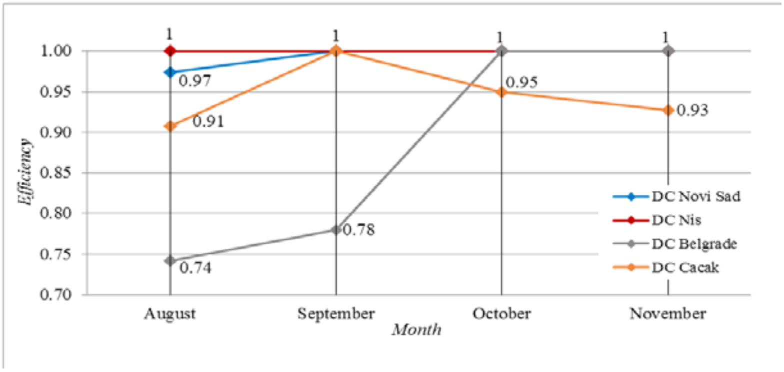

Fig. 4.
Trends of DC Fleet Efficiency Change

5.4. Corrective Measures

Based on the results of driver efficiency and analysis of input data, differences between DMUs that are efficient and those that are not are noted. The possible reason for driver inefficiency is poor management, namely poor organization of driver work, inadequate routing, insufficient vehicle usage, non-use of modern information and communication technologies (ICT), etc. The existence of overtime hours of drivers was noticed, which could be a consequence of inadequate routing, improper driver control, insufficient driver motivation, monitoring of inadequate indicators and similar. One possible way to reduce overtime is to use advanced vehicle and driver monitoring systems, which would also be used to direct the vehicles and avoid traffic jams. Furthermore, the application of contemporary ICT can reduce transport errors. Errors in transport present returned deliveries and the reasons can be various (damage to the goods, delayed or incomplete delivery, poor information of the customer on the location and time of delivery, etc.). The application of ICT can improve customer relations and reduce transport errors, thus reducing time and money losses in the distribution process. Fuel consumption is affected by vehicle type, load capacity, distance travelled, driving style, etc. Some of the methods that could be applied for fuel consumption are, primarily, good planning and routing of vehicles, maximum space and time utilization of vehicles, motivating drivers with appropriate bonuses, etc.

The consequences of poor management are reflected from the efficiency of drivers to the (in) efficiency of the vehicle fleet. The company does not have modern information systems for fleet management, and monitoring the performance of the business is realized manually. This means that each driver independently enters his working hours, the distance travelled, the number of realized deliveries and other characteristics of work. Such a way of monitoring business is outdated and can lead to various errors and malversations. In order to make better use of existing resources, the introduction of a fleet management system (FMS) is proposed to improve fleet efficiency. The introduction of the FMS system would provide detailed insight into vehicle movement, current location, navigation, routing optimization, distance travelled, fuel consumption, driving style, etc. The FMS system enables the company to improve fleet efficiency by providing high visibility of vehicle and driver work in real time, a large number of work analysis tools, efficient communication between drivers and dispatchers and efficient fleet administration. Analysts can create different reports for different periods (daily, weekly, monthly) that would provide decision making support at all levels of the business system. By monitoring and controlling the performance of the vehicle fleet, it is possible to increase the volume of work, to have better time and space utilization of vehicles, lower fuel consumption and emissions of harmful gases. Defining standards and acceptance intervals for Key Performance Indicators (KPIs) enables a response in situations when there are deviations between planned and measured values. One of the global problems is the emission of harmful gases, whereby road transport is one of the biggest polluters in relation to other modes of transport. The European Commission has adopted rules that are applied by the members of the European Union in order to exert influence to reduce this problem. The main strategies of the European Commission to reduce greenhouse gas emissions are (Itkonen *et al.,* 2016):

- Increasing the efficiency of the transport system by using digital technologies and the mode of transport with lower emissions of harmful gasses;
- Use of alternative energy with lower emissions in transport, such as advanced biofuels, renewable electricity, renewable synthetic fuels; and
- Use of zero-emission vehicles.

6. Conclusion

This paper evaluates the efficiency of drivers and fleets for four DCs of one trading company. According to the results of the first study, the average efficiency of drivers is 82%, where only 17.2% is technically efficient. For the first study, an input and output oriented model was made, which, depending on the manager's decision, can be applied to influence the input or output sizes of the model. According to the results of the second study, the average efficiency of fleets is 95%, with 63% of DMUs being efficient and 36% of DMUs being inefficient in the observed period. It can be said that the results of the second study are good, but still, corrective measures could be applied to increase efficiency.

The analysis of the obtained results of both studies indicates insufficient management and poor organization of work in the company. As the company is still undergoing development of its own logistics and constant expansion of its capacities, it is proposed that ICT is applied in all logistics processes for a modern and profitable business. In particular, the application of FMS is proposed for the transport subsystem, which enables insight into vehicle movement, distance travelled, fuel consumption, driver's driving style, navigation, routing optimization, fast communication between driver and dispatcher, exchange of electronic documents using smart devices, etc. All these possibilities increase the efficiency of drivers and fleets, and thus the transport subsystem.

Other DEA models may be used in future efficiency analysis research, such as the BCC DEA model that measures pure technical efficiency and the PCA-DEA approach used to increase the discriminatory power of the standard DEA model. Additionally, the analysis may include KPIs, related to spatial utilization of vehicles, the driver's driving style, paid fines, energy indicators, and similar.

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