Application of the Statistical Analysis Methods for Improving the Managing the Dealer-service Network Efficiency

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Abstract: The article proposes a method to increase the efficiency of dealership service centres (DSC) based on the system analysis use. The method is based on clustering the DSC into groups according to formats, a differentiated approach to the assessment of their activities and the relative useful efficiency calculation. The analysing purpose effectiveness of the dealer-service network (DSN) is to obtain an objective efficiency assessment of each DSC, identify the causes of inefficient operations and develop a strategy for improvement. As a formalization tool, it is proposed to use the software product Konsi-DEA ANALYSIS, which allows to evaluate the parameters of the objects functioning, as well as calculate the coefficients of efficiency and superefficiency for each of them.

1 INTRODUCTION

The main trend in the development of the economy and society, with which intelligent and rational management and development of all activity fields, including the automotive industry, is currently associated is digitalization. In all activity areas, the methods for finding optimal sustainable solutions is associated with the fourth industrial revolution, which is the main trend in the development of the automotive industry. The high motorization level and markets globalization are forcing automakers to search for new solutions, constantly improving both the vehicles design and production technology, as well as new ways to attract customers.

The automotive industry development and growing competition in world markets are leading to the new trends' emergence, such as expanding the assembly plants network in different countries, updating the automotive vehicles' model line, including the emergence of more environmentally friendly and energy-efficient models. Today, the economy's linear model, based on the principle of "take - make - waste", has been replaced by the so-called "circular economy", which has a reducing and closed nature and is based on minimizing the consumption of primary raw materials and reducing waste disposal. All this is completely correlated with such a key direction of the Fourth Industrial Revolution, as the formation of environmentally friendly technical and technological systems. According to research by the international company Persistence Market Research (2015), their introduction to the automotive industry will create an opportunity to reduce raw material consumption by 98%; to save 83% of energy; reduce the finished products cost to 40% and carbon dioxide emissions to 87%. This can be realized in the event that the manufacturer is responsible for his product over the course of its life cycle.

Under these conditions, the task of creating a corporate service system and increasing the processes efficiency in it becomes urgent. In order to ensure customer loyalty, their trust in the brand, the producer company should improve the quality of not only the vehicles produced, but also their subsequent service

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support. The customer focus principle can be implemented by intellectualizing the management and scientific methods using. Modern enterprises operate in conditions of tough competition, which dictates the need to improve their activities' every aspect efficiency. Evaluation of the enterprise functioning effectiveness is based on identifying and systematizing the functions performed by the enterprise and in the selection of indicators that allow you to perform a information qualitative analysis and make decisions based on the results obtained. In this case, the selected methods should provide an increase in the analysis accuracy and prediction in evaluating the effectiveness.

There are three main methods groups for measuring performance: use of economic factors as variables reflecting the enterprise efficiency; mpirical (expert) performance evaluation methods; methods based on creating effectiveness' confines.

Considering the corporate service's system of as one of the subsystems of a vehicles manufacturer, functioning in close cooperation with production and logistics systems, the connection between which is carried out using information and material flows, we can affect the efficiency and sustainability of the entire system, which increases vehicles competitiveness and consumer confidence in the brand.

2 EXISTING METHODS FOR ASSESSING THE AUTO SERVICE EFFECTIVENESS

Customer focus and processes optimization by reducing losses are the main goals of the transition to Industry 4.0. The need for production systems' constant adjustment to customer variable requirements stimulates the development of new methods in the framework of process organization or production control (Trojanowska et al., 2011).

The automotive industry development is the country's industrial standard, according to which the vehicles number in a country can be considered as an indicator of the living standard. That is why industrialized countries will seek to develop the automotive industry. The authors of the article (Maritz, Alex et al., 2013) as a basis for research in the automotive industry in 2007-2009 integrated data coverage analysis (DEA) and Malmquist performance analysis to measure total efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) of nine automotive enterprises in Taiwan to further improve the manufacturers operational efficiency.

The research (Kumar, 2017) aims to measure and evaluate the performance of vehicles manufacturers in India using the DEA, which provides management with information on the most efficient vehicles manufacturing companies in the observations set and identifies relatively inefficient companies compared to the most effective. The authors believe that the main factor leading to their poor performance is excessive employee costs. Therefore, enterprises must dismiss some employees, or reduce the costs of employee benefits.

To optimize the processes using various methods or combinations thereof. As a rule, this is an effectiveness assessment and identification of "limited" places for the subsequent processes modernization. The document (Lee et al., 2010) DEA-based analyses the performance of twenty retailers of two Taiwanese car dealers, combined with practical automotive industry experience. The authors select important input and output variables for evaluating effectiveness to identify the causes of inefficiency, and also suggest ways to improve project management. The DEA is introduced to evaluate the performance of each automotive company retailer. The result makes it possible to develop operations management strategies for car dealers in the future in accordance with an important goal for all car retailers - maximizing revenue and permanent job. In addition, it is important to strengthen the ability of vendors in the field of archiving in customer services and increase customer loyalty and stability.

The article authors (Hladík, 2019) propose a new DEA method for calculating efficiency indicators. The method is based on reliable optimization: higher estimates for those decision-making units (DMU), which remain effective even for large simultaneous and independent changes of all data and vice versa. The approach novelty is that it preserves the ranking order in comparison with the classical approach and is a single invariant. It is naturally normalized, so it can be used to calculate unrelated models' universal DMU indices, which makes it possible to evaluate both inefficient and effective decision-making units. The method can be extended to generalized or alternative models, for example, for processing interval data. The new approach can be adapted to reliability and to other used measurement methods, such as super-efficiency models or cross-effectiveness. Particularly promising are recent results in assessing cross-performance, two-step and network DEA, probabilistic approaches, and DEA models with uncertainties.

Currently, the decision-making process is confronted with various problems that need to be taken into account and planned, since, for example, programs in the automotive industry related to vital human factors are not structured (Baghery et al., 2018). One way to evaluate potential failures of a product or process and their consequences is the process failure mode and effects analysis (PFMEA), which identifies actions to eliminate failure or reduce their effects throughout the product life cycle. A well-known method for prioritizing failures is the risk priority number (RPN). The authors have proposed a new approach to setting priorities in the uncertainty condition. In addition, a new score was used to calculate the risk of each production process. In fact, the assessment obtained from the combination of the DEA interval methods and the Gray relational analysis (GRA) reduced the traditional method problems, since the production processes were prioritized on their criticality basis. At this stage, the SOD factors (severity, occurrence, and detection) were considered as input to the DEA interval model. Then, the first stage results were used as input data in the GRA method for determining the priority of parts manufacturing processes. Finally, some suggestions were made to avoid potential disruptions in auto parts production processes, and some measures were taken in this regard.

Given the fierce competition between large companies, in recent years, a sustainable supply chain has been recognized as a key component of corporate responsibility. The supplier's classification can facilitate the selection of a suitable supplier for management, which saves the company time and cost. DEA has become one of the most commonly used tools for measuring the supplier's relative performance. The article authors (Tavassoli et al., 2019) proposed a new super-efficient stochastic model DEA for measuring the supplier's relative effectiveness in the presence of zero data. The proposed method has many advantages for practitioners in the sustainability field and supply chain management: first, the proposed model can rank all providers in sustainability terms. Secondly, the recently developed stochastic model DEA with high efficiency provides an optimal solution using cost savings and output surplus for efficient suppliers. Third, the newly developed DEA-DA can predict new supplier group membership with high accuracy in a stochastic context.

The article (Rashidi, 2019) presents a results comparative analysis achieved in identifying the most preferred steady suppliers, using two widely used methods - methods for Technique for Order Preference by Similarity to Ideal solution (TOPSIS) and DEA. Fuzzy DEA and fuzzy TOPSIS apply to a common set of logistics service providers in Sweden. Sources of initial materials and the associated supplier selection process are important strategic decisions and actions in any organization. Research is important for interested parties because it indicates future research directions: comparison of suppliers' sustainability assessment methods; sensitivity results analysis to the number and nature of the criteria included in the analysis; solution to the problem of data collection. The results show that the suppliers rating depends on the method. Recognizing the assessment methodology, suppliers should be motivated to respond quickly to the sustainability requirements of the procuring customer.

Choosing a sustainable supplier is the process of identifying the right partners for the supply organization with the best value for money while reducing the various effects of its activities on society and the environment. Therefore, it plays an important role in promoting the organization towards sustainable development. This article (Moheb-Alizadeh et al., 2019) aims to develop an inclusive multi-purpose model of mixed integer linear programming that takes into account several periods, several products and multimodal transportation to evaluate suppliers and distribute order volumes. Among all the Pareto-optimal solutions to the original multi-purpose programming problem, a preferable solution is reasonably chosen based on the DEA super-efficiency indicator of all procuring firms as a decision support tool. The applicability of the proposed approach is illustrated by the example of practical use in the automotive industry.

Since the beginning of the 90s, many world countries began to pay great attention to the environment and raw materials resources. This interest has led to the emergence of a number of new concepts in the industry, including reverse logistics (RL). To solve these problems, scientists use an effective class of methods called metaheuristics. The article authors (Rachih et al., 2019) classify previously published articles on RL on the basis of metaheuristic approaches and the problematic context of the reverse supply chain.

Article (Wang et al. 2019) explores seven enterprises from the Shanghai Professional Committee for the vehicles disposal. The authors believe that the proposed decision analysis using several attributes in the ELV industry will facilitate the ELV processing industry's management. Empirical studies in this article indicate the following. (1) The projection value of relatively inefficient DMU can be calculated by combining triple exponential smoothing and DEA, which provide the increasing efficiency goal, while a slight improvement in inefficient DMU can be used to build a decision matrix for efficiency. (2) The preferred solution can be selected from the decision matrix by combining the entropy weight method with TOPSIS. In addition, comparison of decision making alternatives on additive weighting, weighted product and ELECTRE (Elimination et Choice Translating Reality) and TOPSIS alternatives can be performed to test the stability of the decision process with several attributes. (3) Finally, a combination of the above methods is an effective decision-making method with several attributes to increase the efficiency of the ELV industry with several input and output indicators.

Recycling is aimed at preventing rapid depletion of natural resources when converting received waste into value for the economy. However, this process is becoming a serious problem in the automotive industry, which requires the joint participation of several players in a complex supply chain. The study (Kusakcı, 2019) aims to develop a fuzzy mixed integer positioning model for the ELV RL network in accordance with the directives in force in Turkey. Accordingly, this study uses a new approach and assumes that the ELV supply on the network is uncertain. The proposed mathematical model's merits are proved in a real scenario, which solves the problem of designing RL for ELVs generated in the Istanbul metropolitan area.

The article goal (Hao Hao, 2018) was to improve the reverse supply chain's management in the automotive industry in the context of environmentally friendly, circular and sustainable development by predicting the number of vehicles with an expired service life to be processed, by creating a multi-factor model. To solve the problems associated with nonlinear characteristics and the uncertainty of the recyclable end-of-life vehicles' number, as well as taking into account the many factors affecting the recirculation's number, this article presents a combined forecasting model consisting of a grey model, exponential smoothing and an artificial neural network, optimized by the particle swarm optimization (PSO) algorithm.

Faced with the contradiction between the rapid growth in the vehicle owners' number and the low return rate of end-of-life vehicles, RL services carried out by third-party companies for the processing and ELV dismantling in China are experiencing major problems in a low carbon economy. This document builds a four-level model of a RL network, which includes ELV sources, collection centers, recovery centers, and dismantling. The article authors (Xiao et al., 2019) have developed a mathematical model of mixed integer linear programming (MILP) for solving a problem using the Lingo global optimization software. The MILP model is designed to minimize overall costs (location, transportation, and environment) arising from improper management of the ELV. The model successfully takes into account the location, number and power level of key objects at the same time, which increases the RL network model's complexity and fills the existing gap in research. This provides important management implications for the ELV reverse logistics system at two levels: the macro environment and the micro-industry. For the micro-industry, logistics managers must rationally distribute the number and key facilities' capacity level in the network, including the collection and dismantling center, based on actual demand, and reduce resources waste and environmental pollution. Further research may develop stochastic or fuzzy MILP models that take into account unspecified ELV quantities. In addition, it is possible to design a closed supply chain network, which direct consists and RL for the simultaneous processing of the ELV, in order to analyse the environmental impact on different network participants.

As can be seen from the above review, the method choice depends on the problem being solved. Nevertheless, the DEA is a good optimization tool in management tasks at different stages of the life cycle in the automotive industry.

3 RESULTS AND DISCUSSION

3.1 The Indicators System for Evaluating the Auto Service Effectiveness

The dealer-service network (DSN) is a complex system consisting of dealer service centers (DSC) with three subsystems that operate in close cooperation, i.e. implemented on the principle of "3S" (Sales, Spare Parts, Service). The DSN development has two directions - the construction of new and the reconstruction of existing service centers. The development strategy includes the effectiveness evaluating stage of the existing network to identify leaders and outsiders, determine the using possibility existing development potential, taking into account the regional development strategy and the vehicle fleet structure. The direction of DSN development depends on the analysis results and the effectiveness of the existing DSN.

For an adequate comparison effectiveness of the existing DSC, we must bring their indicators to a comparable form. Each such DSC has potential capabilities that can be numerically designated by a parameters set. The activity of any of these DSC is to strive to maximize apply their capabilities, what can be represented as a desire for an ideal system. The ideal system, in this case, is such a system that reaches the possibilities limit in its activity. Thus, we must understand that there are enterprises that are similar in their capabilities and activities. These enterprises can be ranked according to the achievement indicators degree of an ideal system. Since any DSN is comprised of DSC with different potential, before comparing their effectiveness, it is necessary to cluster them into comparable groups.

If the service needs are not met in a separate region, then it is necessary to consider options for adjusting the development strategy:

1) if the existing DSN is inefficient, and DSC have reached the limits of their capabilities, then the DSN needs to be expanded (either upgrading existing enterprises or building new ones);
2) if the existing DSN works inefficiently, but the DSC has not reached the possibilities limit, then it is necessary to identify the inefficiency causes and stimulate the efficiency's growth;
3) if the existing DSN is working effectively, but there is a significant gap between the leaders and the outsiders, then the strategy should be revised and the resources should be adjusted.

For these purposes, i.e. to evaluate the DSN effectiveness and to choose the development strategy, the authors developed an algorithm (Buyvol et al., 2017), which consists of several stages (Figure 1).

At the first stage, it is necessary to evaluate the effectiveness of the existing region DSN, including in terms of its expansion possibility:

- clustering of the DSC into single-format groups by characteristics (parameters characterizing enterprises in terms of types of activities, volumes of services, etc.) and services provided types for comparability of performance estimates;
- identifying leaders and outsiders within single-format groups, for which it is necessary to determine the input parameters characterizing the potential of the DSC under study and their capabilities, which are defined as the resources used in the work; and the conditions in which the DSC operates, as well as the output parameters that reflect the its results activities.

Under efficiency on this case is understood as the ratio of output parameters to input. The DSN subject will be effectiveness if, at the current value of the input parameters, it is impossible to achieve large output values. For the outsiders identified as a result of this phase, a SWOT analysis is carried out, which allows to determine the strategic planning directions, identifying the strengths and weaknesses of the enterprise, as well as identifying threats and opportunities for development.

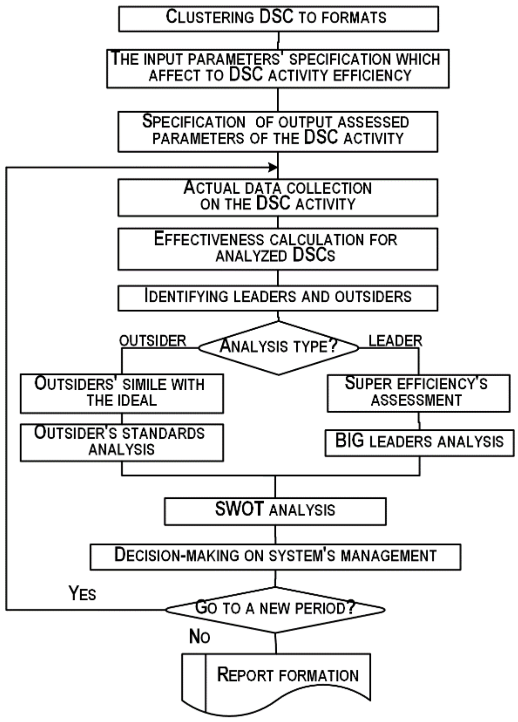


Figure 1: Algorithm for evaluating the effectiveness of the DSN functioning.

The second stage consists in a comprehensive assessment of the regional needs for vehicles-care services under region’s development different scenarios. To perform the analysis, you need:

- assess the current state of the park and fulfil the forecast of changes in its structure under different development scenarios;
- calculate the need for services under different development scenarios;
- assess the capabilities of the existing DSN to meet the needs for corporate service operations at various development scenarios;
- determine the most appropriate scenario for the DSN development, taking into account investment risks.

At the third stage, the chosen strategy adequacy is assessed: determination of the current performance DSC indicators and the complex indicator values of the DSC effectiveness at the period beginning; monitoring system status and comparing performance indicators with baseline ones; indicators analysis, problem situations identification and strategy adjustment.

To assess the DSC effectiveness, various analysis methods are used, one of which is the DEA method, that allows to evaluate the objects functioning parameters, which implemented in the Konsi-DEA ANALYSIS software package (Makarova et al., 2012). The DEA method is based on creating effectiveness' confines and finding the relative performance of each object studied. This method is used to assess the effectiveness of homogeneous objects systems that are engaged in the same activities, while using the same resources. With this approach, the DSC efficiency is assessed by comparing it with the "ideal" enterprise, which works "at the limit" and at the same time uses the resources at its disposal in an optimal way.

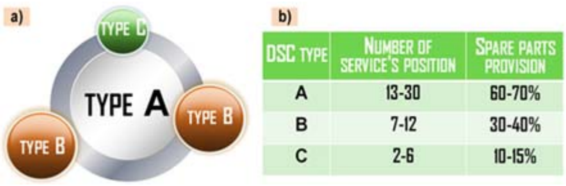
DEA-analysis allows you to highlight the leaders and outsiders in their format groups, compare them with the standards and develop objective strategic solutions for taking the enterprise to the leaders. The outsider indicators analysis suggests a changes assessment to which the DSC parameters should be subjected in order to increase the its activities effectiveness. To make changes in the outsider's work, it is necessary to compare it with the standard (enterprises involved in the formation of the ideal).

Customer satisfaction and loyalty are described in a non-linear function, according to which it is beneficial for an enterprise to achieve a high degree of client loyalty, and not to be content with an average level, because the regular customers circle can be formed only at the funds expense spent on increasing their loyalty (Buyvol et al., 2012).

Potential financial benefits manifest themselves in the long term, while the consequences of consumer dissatisfaction manifest themselves much faster and can be significant, since the secondary effect can negatively affect to future services provided volumes. For service companies (b2c), customer satisfaction score should be above 80%. In case it exceeds 90%, it can be argued that the company has become one of the leaders. To achieve customer loyalty in a highly competitive environment, it is necessary to achieve a high degree of satisfaction with the services provided. This means that the company needs to raise the level of quality of service to a value that is impossible (or extremely difficult) to copy.

Therefore, it is no coincidence that the ISO 9004-2000 standard for enterprises certification of prescribes the mandatory monitoring of the own consumer's satisfaction (clients, customers, buyers) as one of the indicators of the quality management system efficiency (ISO, 2000). Based on the selected performance indicators, a comprehensive system for assessing the DSN subject was developed.

Since the DSC differ in the work performed types, the results assessment of their activities should also be carried out differentially, highlighting for each homogeneous group its own factors list affecting the efficiency of the results and, consequently, the enterprise competitiveness. In this sense, the distinction should be made both of the indicators themselves and of their values for different DSC types and also the subjects themselves should be separated into one-format groups. To classify DSC, you can use a complex indicator characterizing the its project potential. As a rule, when creating DSN in the regions, the following scheme is used: in the "bush's" center there is a large DSC of format A, and on the "bush's" periphery, depending on the specific location, there are DSC of format B or C (Figure 2a). In this case, standard DSC formats are used (Figure 2b).



DSC TYPE	NUMBER OF SERVICE'S POSITION	SPARE PARTS PROVISION
A	13-30	60-70%
B	7-12	30-40%
C	2-6	10-15%

Figure 2: a) disposition scheme DSC in region; b) DSC parameters of different formats.

To find the relative effectiveness of each studied DSC, it is need to determine the input and output parameters, and the ratio of these parameters will determine the effectiveness. Due to territorial dissociation, as well as differences in the functioning parameters, for the effective DSC work, there should be a single managing centre, which should receive timely and operatively information about the productivity indicators of each DSC. Adjustment of the development strategy of the DSN, as well as, in the short term, a change in the managing actions and the resources redistribution, should take into account the analysis results of the incoming operational information.

Analysing the information received, at the first stage, the DSC productivity indicators are determined, and then the ineffective activity causes are identified. If the current efficiency is so low that it casts doubt on the enterprise existence, then the strategy should become short-term and focus primarily on preventing the funds outflow. Even if the DSC works effectively, it does not follow from this that it is necessary to adhere to the chosen strategy. The market is constantly changing, and the strategy role is to help the company quickly adapt to changes in the market. Significant reserves for improving the competitiveness and corporate service system's stability are rooted in the management improvement. One of the methods widely used nowadays involves monitoring the system efficiency indicators and comparing their values in the previous and present periods. Decision making is carried out depending on how the indicators values have changed.

3.2 Methodology for Evaluating DSC Effectiveness

In order to assess the performance of each DSC indicators were comparable, it is necessary to calculate the relative indicators for each activity. When DSN analysing, we proceeded from the fact that the services rendered volume, relative to the number of work station (K_{WST}), is an output parameter. The following parameters were chosen as input parameters: using of the production premises area (K_{PPA}), warehouse space (K_{WS}), work station operating time ($K_{op.t}$).

K_{WST} - work station use rate - is the ratio of the services rendered volume to the number of work station. This indicator allows to evaluate the work organization, personnel qualification and work mechanization. The better the work organization indicators, staff qualifications and mechanization of work, the higher the efficiency of the work station use:

$$K_{WST} = {}^{V}/_{x} \quad (1)$$

where V - the volume of services rendered, mln. rub; x - the number of work station, units.

K_{PPA} - coefficient of technical workroom area use - the ratio of the maintenance and repair (M&R) area to the number of vehicles' maintenance work station:

$$K_{PPA} = {}^{S_{M\&R}}/_{x} \quad (2)$$

K_{WS} - coefficient of warehouse space use - is the ratio of the warehouse space area to the work station number:

$$K_{WS} = {}^{S_W}/_{x} \quad (3)$$

$K_{op.t}$ - the coefficient of operating time use is the ratio of services rendered volume to the product of the number of work station and hourly productivity:

$$K_{op.t} = {}^{V}/_{(x \times y)} \quad (4)$$

$$y = T_{wsh} \times N \times D_{op.y} \quad (5)$$

where T_{wsh} is the work shift duration, an hour; N is the number of work shifts; $D_{op.y}$– the number of operation days in a year, days.

In order for the calculated efficiency absolute indicators to be combined into one general aggregate efficiency indicator, their conversion to the benchmarkable indicator, reflecting the possibilities maximum, is need. Evaluation of the DSS effectiveness involves the use of a complex indicator q, which is defined as the product of indicators:

$$q = \prod_{n=1}^{k} K_k = \frac{K_{PPA}}{K_{PPA}^{bm}} \times \frac{K_{WS}}{K_{ws}^{bm}} \times \frac{K_{op.t}}{K_{op.t}^{bm}} \times \frac{K_{WST}}{K_{wst}^{bm}} \quad (6)$$

where k is the number of indicators.

The complex indicator for assessing the DSN competitiveness is defined as the arithmetic mean of the complex rating DSC indicators and serves as an evaluative measure of the whole network:

$$Q = {}^{\sum q_n}/_{n} \quad (7)$$

For DSC different format groups, the minimum requirements for the general indicators are different. They are used to evaluate the DSC (number of personnel, minimum technical workroom's area, warehouse space placement, administrative and household rooms, parking lots, the minimum equipment set, special tools and accessories, M&R documentation). These indicators are divided into two groups: design parameters ("etalon"), affecting to DSC efficiency, and output calculated parameters.

The design parameters characterize the potential of the DSC under study and their capabilities, they are defined as the resources that are used in the work, and the conditions in which the DSC operates. The estimated parameters for DSCs of different formats should also vary and reflect the activities results both in vehicles sales and spare parts (turnover of spare parts and sold cars) and in service (services volume rendered by activity type, customer satisfaction with the services quality, percentage loading work station).

To evaluate the performance of both individual DSCs and DSNs in general, it is necessary to have the initial design parameters of them each, as well as statistical information about the parameters of their functioning in different periods. Therefore, for each typical service center, the optimal its operational indicators are determined, corresponding to the projected design capacities (profitability, profitableness, costs level per client, etc.).

Since the effectiveness of DSC each, regardless of its format, is characterized by the achievement degree of each limiting values of the input design parameters, it is more logical to use relative unit performance indicators to compare the integral indicators of the DSC functioning in each group. Therefore, at the first stage, relative indicators are calculated, characterizing the achievement degree of the maximum values of these parameters, who will be taken as single performance indicators.

Thus, each DSC will be characterized by indicators set that comprehensively and adequately reflect its competitive potential. At the same time, given that the initial indicators set has a different physical meaning and the impact nature on the final DSC competitiveness assessment, they were divided into groups: I_1 - indicators, the growth of which leads to an increase in the overall DSC assessment (for example, the growth of staff qualifications has a positive effect on the productivity); I_2 - indicators, a decrease in which leads to an increase in the overall DSC rating (an increase in customer waiting time in the queue adversely affects the image of the enterprise and thereby reduces efficiency). To bring their impact nature on the final assessment to a single base, the indicators values of the second group should be converted by the formula:

$$I_2 = {}^{1}/_{I_1} \tag{8}$$

Then DSC are divided into homogeneous “single format” groups, for which efficiency indicators and use of production capabilities are analysed. DSCs are compared with each other, the best use of production capabilities is determined, and leading enterprises and outsider enterprises are identified. DSC is effective if at the current value of the design parameters it is impossible to achieve large values of the output parameters.

In order for the comparison to be correct, at the first stage we divide the entire existing data array about DSC into 3 groups, according to their format, i.e. quantity of work station. Since DSC even into one-format groups, have different potential for development, it is expedient to evaluate their production capabilities from this point of view. In order for the comparison to be correct, the indicators reduced to the number of work station are calculated. Then ranking is carried out for each of the factors and the total rank is calculated. The algorithm of DSC classification by design parameters is shown in Figure 3. Thus, we obtain data on the potential, which can later be used to build a DSN development strategy.

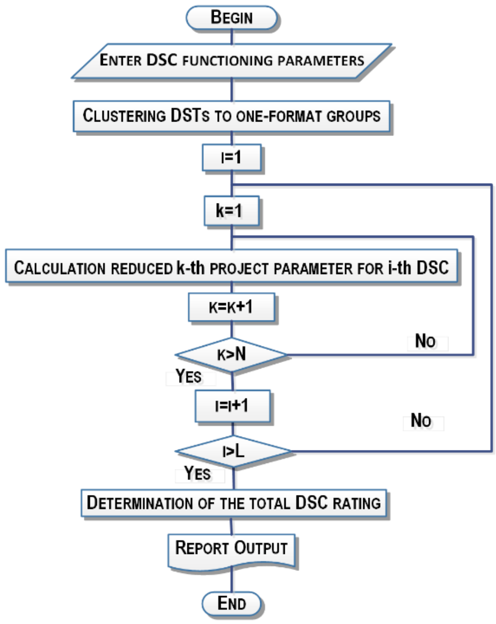


Figure 3: Algorithm for DSC classification.

3.3 An Example of the Developed Methodology Implementation

In order to realize the developed methodology for adjusting the development strategy for DSN, a software implementation of the developed algorithm was performed based on their activities analysis. Ranging example of the DSC of format A is given in the Figure 4.

Due to the availability of the upload and download function of periodically generated files with data coming into the managing center, the statistics of the DSC activity results is accumulated, which can be used to analyse data in comparison with the results of previous periods and etalon values.

This program advantage is that its use minimizes the subjective factors impact on the qualitative and quantitative information assessment on the enterprises activity and facilitates the adoption of informed decisions based on its analysis without the expert involvement. The information in the program module window is divided into tabs in accordance with the rating categories. Protection is provided against the input of incorrect information (information is entered strictly in accordance with the data types), as well as the mandatory filling out of the established list of fields is prescribed (with the turning possibility off the reminder of field completeness checking).

After entering the information into all the required

DSC	Number of work stations	AREAS							RELATIVE INDICATORS							RATINGS							SUMMARY RATING
		Summary	Sales	Zone M&R, including washing and cleaning construction	Office Rooms	Administrative complex	PARKING	WAREHOUSES	1	2	3	4	5	6	7	1	2	3	4	5	6	7	
Alpha	24	41208	15300	3552	2879	192	15300	6077	1717	638	148	120	8	638	253	1	1	5	1	10	1	2	21
Beta	17	11843	1229	2680	110	1845	1229	5979	697	72	158	6	109	72	352	4	7	4	7	1	7	1	31
Gamma	24	9751	3539	2670	165	531	3539	2846	406	147	111	7	22	147	119	6	3	9	5	6	3	3	35
Delta	16	20644	3400	1492	30	456	3400	540	1290	213	93	2	29	213	34	3	2	11	11	5	2	7	41
Epsilon	24	9751	3539	2670	165	531	3539	2846	406	147	111	7	22	147	119	7	4	10	6	7	4	4	42
Zeta	20	10243	1000	6756	90	1905	1000	492	512	50	338	5	95	50	25	5	8	2	9	2	8	9	43
Iota	26	7612	2600	3091	500	858	2600	563	293	100	119	19	33	100	22	9	6	7	3	4	6	10	45
Kappa	30	9530	800	6656	750	1007	800	317	318	27	222	25	34	27	11	8	11	3	2	3	11	11	49
Lambda	25	33532	800	31700	48	336	800	648	1341	32	1268	2	13	32	26	2	10	1	10	9	10	8	50
Sigma	26	6950	920	3600	400	510	920	1520	267	35	138	15	20	35	58	10	9	6	4	8	9	5	51
Omega	20	3010	2000	2235	110		2000	900	151	100	112	6	0	100	45	11	5	8	8	11	5	6	54

Figure 4: The calculation results of total ratings for DSC format A.

Figure 5: The program's window for choosing the DSC development strategy based on the analysis results of their activities.

fields, the specialist responsible for collecting information on all DSC sends the file with the data that is loaded into a single database in the main managing center. A DSN specialist of efficiency evaluation uploads data from all DSCs to a single database. The program allows calculating the relative indicators for each DSC, comparing them with the etalon values. After that, the change in indicators comparing to previous periods is analyzed, the value of efficiency is calculated as for each DSC, so for the DSN in general. Based on this data, the correctness of the chosen strategy is analyzed (Figure 5).

As a result of the DEA-analysis of the DSN efficiency, it was established that five out of eleven DSC are working with sufficient efficiency. DSC was selected, which works with low efficiency. To identify its strengths and weaknesses, a SWOT analysis was conducted, and positive aspects were identified, including a convenient operating mode and a small number of competitors in the region. A comparative analysis of the activities of this DSC for past periods has shown that the deterioration of the complex indicator is caused by a decrease in the work station use rate and the coefficient of operating time use, which requires identifying the causes of these indicators deterioration and adjusting the development strategy.

$$q_{1\,year} = \prod_{n=1}^{k} K_k = 0.58 \times 0.62 \times 0.49 \times 0.49$$

$$q_{2\,year} = \prod_{n=1}^{k} K_k = 0.58 \times 0.62 \times 0.44 \times 0.44$$

Comparative analysis of the integrated indicators of the dealer-service network by years suggests that the chosen strategy was effective, since there is a positive trend.

$$Q_{1\,year} = {\sum q_n}/{n} = {1.986}/{12} = 0.17$$

$$Q_{2\,year} = {\sum q_n}/{n} = {2.174}/{12} = 0.18$$

In the DSC, where production capacity is fully involved, the question of achieving the maximum optimal managing is raised. For the DSC, which have not exhausted their production capabilities, the reasons for low efficiency are identified, the input parameters are highlighted, the adjustment of which will allow organizing processes more rationally, a measures plan is developed for their optimization. After this, the analyst assesses which improvements will bring the planned activities to each DSC and the system as a whole. Developed activities are brought to the DSC attention for further implementation.

4 CONCLUSIONS

This research's practical significance lies in the fact that the developed algorithms use and techniques contributes to improving the service vehicles quality, and ensuring the effective implementation of their resources and improving the service level in the DSC by improving the quality of science-based management decisions. A general method of increasing the competitiveness of the DSC and DSN as a whole is proposed. This method based by highlighting the assessment factors and the parameters affecting them, calculating the "etalon" and actual values and adjusting the managing action depending on the actual values degree of deviation from the "etalon" values. Thus, consideration of the DSN in the complex will allow identifying leaders and outsiders among the DSC in format groups, develop a plan for changes in the DSC operation and implement a reasonable redistribution of resources between the DSC within the DSN.

REFERENCES

Baghery Majid et al. Risk measurement and prioritization of auto parts manufacturing processes based on process failure analysis, interval data envelopment analysis and grey relational analysis. *J Intell Manuf* (2018) 29:1803–1825

Buyvol, P. at al. Improving the branded service network efficiency based on its functioning evaluation. *Astra Salvensis*. Vol. 2017, 2017, Pages 373-385

Buyvol, P.A. et al. Management of Automobile Plant Dealer-Service Network Efficiency by Means of Decision Support System. *Third Forum of Young Researchers: in the Framework of International Forum Education Quality* - 2012 Pages: 202-207 Published: 2012

Hao Hao et al. Forecasting the number of end-of-life vehicles using a hybrid model based on grey model and artificial neural network. *Journal of Cleaner Production* 202 (2018) 684e696

Hladík Milan. Universal efficiency scores in data envelopment analysis based on a robust approach. *Expert Systems With Applications* 122 (2019) 242–252

ISO 9004:2000. Quality management systems -- Guidelines for performance improvements. https://www.iso.org/standard/28692.html

Kumar Nand et al. Evaluation of Efficiency of Automobile Manufacturing Companies in India Using Data Envelopment Analysis. *International journal of advanced production and industrial engineering.* IJAPIE-2017-01-111, Vol 2 (1), 01-06

Kusakcı Ali Osman et al. Optimization of reverse logistics network of End of Life Vehicles under fuzzy supply: A case study for Istanbul Metropolitan Area. *Journal of Cleaner Production* 215 (2019) 1036-1051

Lee C.C., Chang F.T. A Performance Management on Automobile Dealers with Applying Data Envelopment Analysis. *Proceedings of the 2010 IEEE IEEM*. Pp.380-384

Makarova, I. et al. Dealer-service center competitiveness increase using modern management methods. *Transport Problems* Vol: 7 Iss: 2 pp. 53-59 (2012)

Maritz, Alex, Shieh, Chich-Jen. Performance Analysis of Automobile Industry in Taiwan with Data Envelopment Analysis. *International Journal of Applied Mathematics and Statistics,* Vol. 38; Issue No. 8; Year 2013, pp.84-95

Moheb-Alizadeh Hadi, Handfield Robert. Sustainable supplier selection and order allocation: A novel multi-objective programming model with a hybrid solution approach. *Computers & Industrial Engineering* 129 (2019) 192–209

Rachih Hanane et.al. Meta-heuristics for reverse logistics: A literature review and perspectives. *Computers & Industrial Engineering* 127 (2019) 45–62

Rashidi Kamran, Cullinane Kevin. A comparison of fuzzy DEA and fuzzy TOPSIS in sustainable supplier selection: Implications for sourcing strategy. *Expert Systems With Applications* 121 (2019) 266–281

Tavassoli Mohammad, Saen Reza Farzipoor. Predicting group membership of sustainable suppliers via data envelopment analysis and discriminant analysis. *Sustainable Production and Consumption* 18 (2019) 41–52

Trojanowska, J. et al. Influence of selected methods of production flow control on environment. In: Golinska, P., Fertsch, M., MarxGomez, J. (eds.) *Information Technologies in Environmental Engineering*, pp. s.695–705. Springer, New York (2011). doi: 10.1007/978-3-64219536-5_54

Wang Zhiguo et al. Multi-attribute decision making on reverse logistics based on DEA-TOPSIS: A study of the Shanghai End-of-life vehicles industry. *Journal of Cleaner Production* 214 (2019) 730-737

Zhongdong Xiao et al. Location-allocation problem of reverse logistics for end-of-life vehicles based on the measurement of carbon emissions. *Computers & Industrial Engineering* 127 (2019) 169–181