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USE OF INTEGRATED MCDM APPROACH FOR THE SELECTION OF LEAN TOOLS TO IMPROVE THE ORGANIZATIONAL-BUSINESS PERFORMANCE

Vladan Paunović
Sanja Puzović
Zoran Nešić[1]
Jasmina Vesić Vasović

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A B S T R A C T

There are numerous strategies and concepts that management can use in order to improve the organizational business performance of companies in modern business conditions. Research shows that one of the most prevalent principles in the past few years is the use of Lean tools, which enable managers to continuously improve their business. Since in most cases the problem of choosing Lean tools is solved through experience, the paper proposes the application of an integrated multi-criteria approach for decision-making. The evaluation of the relative importance of the criteria was performed using the AHP method, while the selection of the most suitable Lean tool was carried out using the ELECTRE method, the PROMETHEE method and the Compromise Programming method, using specially developed software for that purpose. The aim of this paper is to point out the importance and quality of the application of the proposed model in real and modern conditions of business and organization.

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1. INTRODUCTION

Modern business conditions require companies to continuously improve their organizational and business performance in a high-quality manner. Due to increasing market competition and increasingly complex customer requirements, companies are required to produce higher quality products, shorter delivery times and lower costs. Many companies face more and more challenges in finding ways to improve performance, which needs to be updated almost on an annual basis. These circumstances only make it difficult to choose the most appropriate approaches, techniques and tools, as they should be applicable and add value to the enterprise.

The paper will present a proposal for a multi-criteria decision-making (MCDM) model of appropriate Lean tools for quality improvement of organizational and technical performance of companies in the metalworking industry. In practice, no single Lean tool can solve all problems and respond to all challenges an organization faces. All Lean tools have their advantages, but also certain limitations, which is why it is necessary to choose a group of the most suitable tools. The managerial initiative to improve quality and improve the company's performance refers to approaches to the use and implementation of the Lean concept and various tools in production systems (Hobbs, 2004; Hobbs, 2011).

Information technology is essential for the practical application of business decision-making methods. In this way, different methodologies of multi-criteria decision-making can be implemented in practice. Modern methodologies of multi-criteria decision-making are becoming more and more complex and

[1] Corresponding author: Zoran Nešić
Email: zoran.nesic@ftn.kg.ac.rs

sophisticated. The task of information technology is to support these methods, but on the other hand to enable users to use them easily. This paper presents a program for using multi-criteria ranking methods using Promethea, Compromise ranking and Electra. The specificity of this program is the possibility of visual presentation and analysis of preferences according to certain criteria using the calculation of the Universal Preference Function. This function allows the creation of an unlimited number of preference functions. The program enables their simple and comparative visual analysis as well as a comparative presentation of the results of other methods of multi-criteria analysis.

2. SELECTION OF THE MOST EFFECTIVE LEAN TOOLS BASED ON DEFINED CRITERIA

By reviewing the literature, many authors propose the Lean concept, that is, the use of Lean tools as one of the best and most effective ways to improve the organizational and business performance of a company. The ability to choose the appropriate tools and techniques of lean manufacturing, taking into account several critical criteria for decision-making, provides a significant improvement in the quality of business (Yahya et al., 2016; Belekoukias, Garza-Reyes & Kumar, 2014).In practice, it has been shown that the use of Lean tools achieves a significant reduction in waste (Leksic, Stefanic & Veza, 2020).According to (Gonzalez et al., 2016) they can serve as a powerful tool for increasing the efficiency of the company.These tools measure the efficiency and quality of work performance (Pakdil& Leonard, 2014).A study conducted by (Reda & Dvivedi, 2022) suggests an innovative approach in selecting appropriate lean tools to maximize the company's core resources, while the case study (Kumar et al., 2021) showed a direct improvement in productivity and improved customer service.The findings presented in research of (Alaskari, Ahmad & Pinedo-Cuenca, 2016) revealed that the proposed methodology was effective in identifying appropriate lean tools for companies, according to key performance indicators in the SME manufacturing sector.Improvements in operational and environmental performance are demonstrated with a change in Lean tool application status (Liu, Niu & Li, 2022).

2.1 Selection of Lean Tools

A significant role in the application of Lean tools in manufacturing companies is played by customers, who can directly influence the added value of the product. They don`t attach much importance to the organizational and production activities of the manufacturer, but are exclusively interested in the quality, correctness and functionality of the product. Table 1. shows some of the most important Lean tools that the management of manufacturing companies use in order to qualitatively improve organizational and business performances.

Table 1. The most important Lean tools for quality improvement of organizational and business performance

	Lean Tools	Definition
a_1	5S	5S is a five-step methodology for creating a more organized and productive workspace: sort, straighten, shine, standardize and maintain.
a_2	Value Stream Mapping (VSM)	VSM is a flow chart that documents each step involved in the material and information flows required to bring a product from order to delivery. It is used in continuous improvement to identify and eliminate waste, reduce process cycle times, and implement process improvements.
a_3	Plan-Do-Check-Act analysis (PDCA)	PDCA - Managers set targets (plans), Teams implement improvements (Do), then they measure (Check) the change to evaluate performance against the target. If the target is accomplished, it standardizes (Acts) the new method by updating the standardized work.
a_4	Poka-Yoke (error avoidance)	Poka-Yoke is a technique that aims to minimize or completely eliminate the possibility of errors and defects resulting from errors, as well as to reduce the possibility of transferring defective products to the next production stage, or to the end user.
a_5	Single-Minute-Exchange of Dies (SMED)	SMED is used in manufacturing to reduce equipment changeover time, it can also help reduce costs and increase flexibility within the process.
a_6	Takt Time	Takt Time represents the quotient of the planned production time and the time required by the customer. It is a method for determining the production rhythm, thereby aligning production with customer requirements.
a_7	Total Productive Maintenance (TPM)	TPM is the process of using machines, equipment, employees and supporting processes to maintain and improve the integrity of production and the quality of systems.

2.2 Criteria to be considered when selecting Lean Tools

The most important step in the application of multi-criteria decision-making methodology is the selection of alternatives and criteria that the decision-maker should consider, in the example of manufacturing companies, these are managers. The criteria for choosing the optimal alternative are of a diverse nature, and managers are required to perform an analysis and

selection of criteria with regard to the qualitative improvement of organizational business performance.
Below are presented the criteria on the basis of which the considered alternatives were evaluated:**C1: Costs**(Costs of scrap and processing; of production per unit; of product;of product development;of transport; Inventory costs etc.); **C2: Quality** (Standardization of procedures and processes; Return rate of customers; Flow time or production time; On-time delivery percentage etc.); **C3: Productivity** (Productivity of labor; Equipment utilization; Capacity utilization; Number of bottleneck stages etc.); **C4: Innovations** (Time to launch new products; Time spent on engineering changes; No. of proposals per employee peryear; No. of new products introduced etc.) **C5: Flexibility**(General flexibility; Product expiration date; Percentage of production equipment that is digitized or automated etc.); **C6: Competitive advantages**(Annual gross profit; Total sales; Market share; Product price etc.) **C7: Morality** (Number of awards and rewards for employees; Employee turnover rate; Communication between employees and management etc.)

3. APPLICATION OF AN INTEGRATED MCDM APPROACH WHEN SELECTING LEAN TOOLS

The paper presents the MCDM model based on the integration of the AHP and PROMETHEE methods, the ELECTRA method and the Compromise Programming Method. It is shown on the example of the evaluation of alternatives when choosing Lean tools for quality improvement of the organizational and business performance of a manufacturing company, which are the most significant in practice. The selection was made between seven alternative tools evaluated in a system of seven criteria. Since the management of the company makes these decisions in modern and dynamic business conditions, in order to perform an accurate evaluation of the considered alternatives, it is necessary to apply the Integrated MCDM approach. The AHP method is used to evaluate the criteria used to evaluate the alternatives, where the weight coefficients obtained below for each criterion will be further used in the process of evaluating the alternatives using the modified PROMETHEE, ELECTRA and Compromise Programming methods (Radojicic et al., 2013). The evaluation process was carried out using specially developed software, where a comparative view of the results will be presented by applying these three methods.

3.1 Evaluation of the weight of the criteria using the AHP method

The hierarchical structure of the problem developed by the AHP methodology is shown in Figure 1.

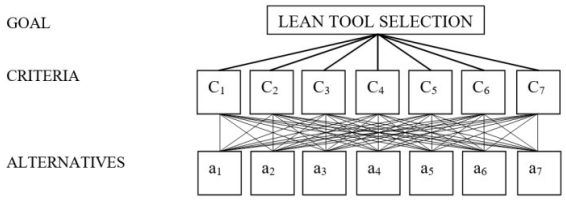


Figure 1. The hierarchy of the decision-making problem

The influence of the criteria on the choice of Lean tools depends on the subjective assessment of the decision maker, in this example the manager, in the conditions of uncertainty in which the decision is made. This would mean that any of the criteria can become crucial in the choice, depending on the situation, and that, also, depending on the criteria used, each of the alternatives can dominate over the others. In order to perform a correct and rational evaluation of the alternatives, it is first necessary to evaluate the relative importance of each individual criterion. The criteria assessment matrix is given in Table 2.
The assessment matrix is further translated into a criteria priority scale by normalizing the weight vector of each individual criterion, the relative importance of the criteria is obtained (Table 3) according to the decision maker's priorities in the considered situation.

Table 2. Revised matrix of pairwise comparison of criterion weights

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
C_1	1.0	0.5	3.0	5.0	6.0	4.0	7.0
C_2	2.0	1.0	4.0	6.0	7.0	5.0	9.0
C_3	0.33	0.25	1.0	4.0	5.0	2.0	6.0
C_4	0.2	0.17	0.25	1.0	2.0	0.33	4.0
C_5	0.17	0.14	0.2	0.5	1.0	0.2	3.0
C_6	0.25	0.2	0.5	3.0	5.0	1.0	0.17
C_7	0.14	0.11	0.17	0.25	0.33	6.0	1.0

Table 3. Criteria weights specified using AHP methods

Criteria	Criteria weight
C1: Costs	0.244742
C2: Quality	0.355284
C3: Productivity	0.142258
C4: Innovations	0.060537
C5: Flexibility	0.04235
C6: Competitive advantages	0.085935
C7: Morality	0.068895

The obtained results indicate that the "Quality" criterion with a weight coefficient of 0.355284 dominates over the other criteria, and the "Flexibility" criterion with a weight coefficient of 0.04235 was the least dominant.This solved the problem of conflicting criteria and imprecise information for their definition and assessment, and the obtained results served in the further process of evaluating alternatives.

3.2 Process of evaluation of alternatives using modified PROMETHEE method

For the considered MDCM problem the evaluation matrix (Table 4) was constructed, which compliantly with the defined hierarchical structure of the problem (Figure 1) encompasses the 7 alternatives assessed in the system of 7 criteria. The evaluation matrix was constructed on the basis of the impressions that managers, involved in the decision-making process, gained during the testing of Lean tools, as well as on the basis of the existing organizational and business performance of the company.

Table 4. The evaluation matrix

Criteria				Alternatives						
	Relative Weights	Request	Type of preference function	a_1	a_2	a_3	a_4	a_5	a_6	a_7
C_1	0.244742	MIN	Universal	2.35	8.14	9	7	1.48	5.73	4.06
C_2	0.355284	MAX	Universal	7.21	8.49	6.15	8	3.3	4.07	9.2
C_3	0.142258	MAX	Universal	9	8	4	3	6	7	5
C_4	0.060537	MAX	Universal	2.6	7.2	9.5	1.1	4.1	3	5.8
C_5	0.04235	MAX	Universal	1.83	2.97	4.71	2.32	5	3.45	0.64
C_6	0.085935	MAX	Universal	5.09	8.83	9.14	7.22	6.84	8.19	5.73
C_7	0.068895	MAX	Universal	10	1.5	8	4	2	7.5	5.5

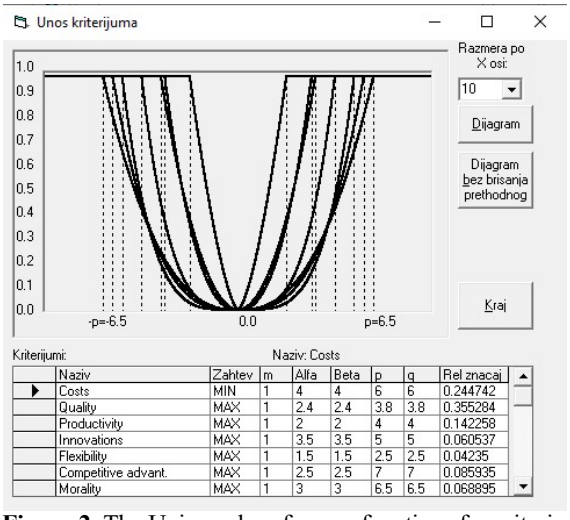


Figure 2. The Universal preference functions for criteria

The further ranking procedure of the considered alternatives according to the modified PROMETHEE methodology was carried out with the use of specially developed software.

The obtained results(Figure 3) indicate that the alternative "5S"singled out as an alternative that has the greatest impact on the improvement of the organizational business performance of the company.

To solve the problem of decision-making and ranking of alternatives, in situations where qualitative criteria are present, the application of the modified PROMERHEE method is suggested.For each criterion, the same type of universal preference function was selected that most appropriately reflects the specifics of the given criteria, after which parameters were determined, as well as requirements for extremism (Figure 2). For the relative weights of the criteria, the results obtained in the previous procedure of evaluating the criteria using the AHP method were used (Table 3).

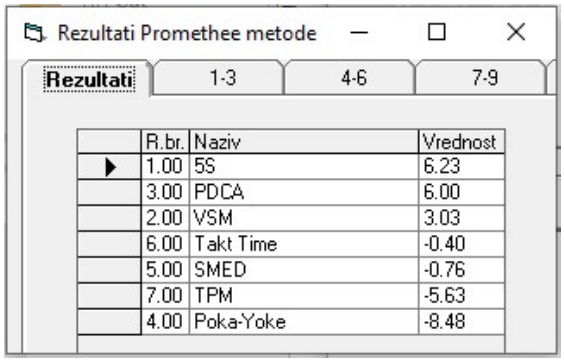
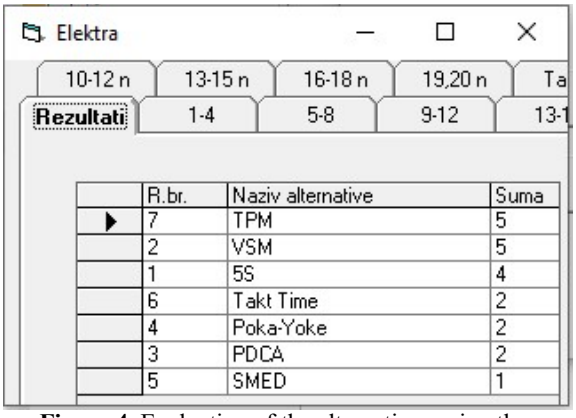


Figure 3. Evaluation of the alternatives using themodified PROMETHEE method

3.3 Process of evaluation of alternatives using ELECTRE method

Furthermore, the ranking of alternatives was performed using the ELECTRA method, based on the parameters from the evaluation matrix (Table 4).

The following ranking of alternatives was obtained (Figure 4), where we can see that it differs from the ranking obtained by the analysis using themodified PROMETHEE method, and that the best ranked alternative is "TPM".



R.br.	Naziv alternative	Suma
7	TPM	5
2	VSM	5
1	5S	4
6	Takt Time	2
4	Poka-Yoke	2
3	PDCA	2
5	SMED	1

Figure 4. Evaluation of the alternatives using the ELECTRA method

3.4 Process of evaluation of alternatives using Compromise Programming method

Also, the ranking of alternatives was performed using Compromise Programming method, based on the parameters from the evaluation matrix (Table 4).

R.br.	Naziv	Vrednost
2	VSM	0.234102218886742
6	Takt Time	0.380747658310454
3	PDCA	1
1	5S	1.19143936204403
5	SMED	1.44489249287218
7	TPM	1.83378924315473
4	Poka-Yoke	2

Figure 5. Evaluation of the alternatives using the Compromise Programming method

Based on the ranked alternatives (Figure 5), we can also see that the final ranking of the alternatives is different from the results of the previous two methods, and that the best ranked alternative is "VMS".

4. CONCLUSION

The results of the comparative analysis of the evaluation of alternatives using three different MCDM methods indicate different rankings of the alternatives. So it can be concluded that none of the proposed Lean tools is dominant compared to the others.The proposed model reduces subjectivity when making decisions and generates much more rational solutions, based on reliable assessment of the weight of criteria, structuring of problems and overcoming problems.On the other hand, the modified PROMETHEE method improves the quality of decision-making by assigning appropriate universal preference functions to each of the criteria and enables a rational ranking of the considered Lean tools.While the application of specially developed software provides decision makers with ease of use, speed and eliminates the possibility of error when solving problems. Therefore, further research is possible on the selection of appropriate lean tools, taking into account several critical decision criteria in modern business conditions.

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Vladan Paunović
University of Kragujevac, Faculty of Technical Sciences,
Čačak,
Serbia
vladan.paunovic@ftn.kg.ac.rs
ORCID: 0000-0002-9641-6873

Sanja Puzović
University of Kragujevac, Faculty of Technical Sciences,
Čačak,
Serbia
sanja.puzovic@ftn.kg.ac.rs
ORCID: 0000-0002-6883-1199

Zoran Nešić
University of Kragujevac, Faculty of Technical Sciences,
Čačak,
Serbia
zoran.nesic@ftn.kg.ac.rs
ORCID: 0000-0001-6004-373X

Jasmina Vesić Vasović
University of Kragujevac, Faculty of Technical Sciences,
Čačak,
Serbia
jasmina.vesic@ftn.kg.ac.rs
ORCID: 0000-0002-9381-0701