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APPLICATION OF THE GREY TOPSIS METHOD TO ASSESS AND SELECT A CONTRACTOR IN TERMS OF OCCUPATIONAL SAFETY MANAGEMENT

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Abstract: The objective of the article is to analyze the possibility of using the gray TOPSIS method to evaluate and select a contractor due to specific criteria regarding occupational health and safety management (OHSM). The choice of contractor is a problem for the decision-maker to make decisions based on many criteria, and most often, these criteria are very diverse, both quantitative and qualitative. The gray TOPSIS method is based on the use of a measure of the relative distance from the best solution, constituting the pattern, and from the worst solution, constituting the anti-pattern, to sort the solutions, using the Grey System Theory. To evaluate and select the contractor, 12 different criteria were used, describing the key areas of OHSM for the decision-maker. The criteria and their weights were selected taking into account the nature of the work planned to be carried out by the company ordering the work. Z-10 annual reports on working conditions in a given year submitted by enterprises to the Central Statistical Office, expert assessments and occupational health and safety procedures provided by five potential contractors were used as sources of information. The research confirmed that the use of gray numbers as part of the TOPSIS method allows the ranking of potential contractors from the point of view of selected criteria and the selection of the company that best meets the assumed occupational health and safety management criteria.
Keywords: making decision, contractor performance evaluation, OHS management, grey TOPSIS

1. INTRODUCTION

Ensuring occupational health and safety is one of the most key issues when choosing a contractor. The literature on the subject states that the high rate of accidents in these companies results primarily from inadequate knowledge of the practice and working conditions in the positions (Clarke, 2003), tendency to take risky actions (Blank et al., 1995), lack of training and insufficient experience in ensuring safety of employees (Kochan et al., 1994), incorrect hazard identification and risk assessment (Salminen, 1995), lack of awareness of the need to maintain safety (Hon et al., 2010), economic pressure and inappropriate organization of work processes (Quinlan and Mayhew, 2000). Accidents affect the functioning of both the contractor and the decision-maker, hence the problem of optimal selection of a contractor becomes one of the most key decisions in the management of occupational health and safety (Holubová, 2016; Klimecka-Tatar and Niciejewska, 2016; Tabor, 2018; Woźny, 2020). Due to the complexity of the contractor selection process, this process can be treated as a decision-making problem with many criteria and a limited number of possible decision variants. In this case, the best solution will be to use a multi-criteria decision-making tool. The literature on the subject provides numerous examples of such tools (Ho et al., 2010; Chai et al., 2013; Govindan et al., 2015), with varying levels of complexity and adaptation to specific problems (De Boer et al., 2001; Jain et al., 2016). Although decision-making is a key management function, in the area of occupational health and safety management, the use of multi-criteria decision-making (MCDM) tools is still little practiced and rarely described in the literature (Tabor, 2018; Niciejewska and Kiriliuk, 2020). One of the more famous and well-described MCDM tools is the TOPSIS method (*Technique for Order Preference by Similarity to Ideal Solution)*, used for linear ordering of variants, which was proposed by Hwang and Yoon (1981). The method is based on the use of a measure of the relative distance from the best solution, constituting the pattern, and the distance from the worst solution, constituting the anti-pattern. The aim of this method is to identify a variant that would be characterized by maximum relative closeness to the pattern and minimum relative proximity to the antipattern (Opricovic and Tzeng, 2004). The basic areas of application of the TOPSIS method include logistics and supply chain management, production management, energy and raw materials management, and environmental management (Behzadian et al., 2012). The TOPSIS method continues to evolve as new methodologies emerge. Nowadays, the most commonly used is the so-called the fuzzy TOPSIS method, using the theory of fuzzy sets (Jain et al., 2016). The basic areas of application of the TOPSIS method include logistics and supply chain management, production management, energy and raw materials management, and environmental management (Behzadian et al., 2012). However, this work proposes the use of the gray systems theory (GTS) and the gray TOPSIS method. Gray systems theory (GTS) is a methodology for analyzing and assessing systems when information about these systems is uncertain and incomplete (Deng, 1982; Li et al., 2007; Liu et al., 2016).

2. METHODOLOGY OF RESEARCH

The prepared procedure for assessing and selecting alternatives using the grey TOPSIS includes the following steps:

Step 1) Assessment of decision criteria;

Step 2) Evaluation of the significance of decision criteria and their aggregation using the arithmetic mean method:

$$\otimes W_j = \frac{1}{K}\left[\otimes W_j^1 + \otimes W_j^2 + \cdots + \otimes W_j^K\right] \, where\!: \otimes W_j^K = \left[\underline{W}_j^K, \overline{W}_j^K\right] \quad (1)$$

Step 3) Evaluation of alternatives using linguistic variables and their aggregation using the arithmetic mean method:

$$\otimes G_{ij} = \frac{1}{K}\left[\otimes G_{ij}^1 + \otimes G_{ij}^2 + \cdots + \otimes G_{ij}^K\right] \quad (2)$$

where: $\otimes G_{ij}^K, (i = 1,2,\dots,m; j = 1,2,\dots,n)$ is an assessment of the criterion by the Kth decision-maker, which is represented by a grey number in a form: $\otimes G_{ij}^K = \left[\underline{G}_{ij}^K, \overline{G}_{ij}^K\right]$.

Step 4) Building a gray decision matrix:

$$D = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & \cdots & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & & \otimes G_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \otimes G_{m1} & \otimes G_{m2} & \cdots & \otimes G_{mn} \end{bmatrix} \quad (3)$$

Step 5) Building a standardized gray decision matrix:

$$D^* = \begin{bmatrix} \otimes G_{11}^* & \otimes G_{12}^* & \cdots & \otimes G_{1n}^* \\ \otimes G_{21}^* & \otimes G_{22}^* & & \otimes G_{2n}^* \\ \vdots & \vdots & \ddots & \vdots \\ \otimes G_{m1}^* & \otimes G_{m2}^* & \cdots & \otimes G_{mn}^* \end{bmatrix} \quad (4)$$

where $\otimes G_{ij}^* = \left[\frac{\underline{G}_{ij}}{G_j^{max}}, \frac{\overline{G}_{ij}}{G_j^{max}}\right]$ and $G_j^{max} = \max_{1 \le i \le m}\{\overline{G}_{ij}\}$ for benefit criteria, and

$\otimes G_{ij}^* = \left[\frac{G_j^{min}}{\overline{G}_{ij}}, \frac{G_j^{min}}{\underline{G}_{ij}}\right]$ and $G_j^{min} = \min_{1 \le i \le m}\{\underline{G}_{ij}\}$ for cost criteria.

Step 6) Building a weighted normalized gray decision matrix:

$$D_W^* = \begin{bmatrix} \otimes V_{11} & \otimes V_{12} & \cdots & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & & \otimes V_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \otimes V_{m1} & \otimes V_{m2} & \cdots & \otimes V_{mn} \end{bmatrix}, where{:}\otimes V_{ij} = \otimes G_{ij}^* \times \otimes W_j \quad (5)$$

Step 7) Determining the pattern - for a set of *m* possible alternatives A={A_1, A_2, A_3, …A_m}, the A^{max} pattern is defined as follows:

$$A^{max} = \{\otimes V_1^{max}, \otimes V_2^{max}, \dots, \otimes V_n^{max}\} \text{ where:}$$

$$A^{max} = \left\{\left[\max_{1 \le i \le m} \underline{V}_{i1}, \max_{1 \le i \le m} \overline{V}_{i1}\right], \left[\max_{1 \le i \le m} \underline{V}_{i2}, \max_{1 \le i \le m} \overline{V}_{i2}\right], \dots, \left[\max_{1 \le i \le m} \underline{V}_{in}, \max_{1 \le i \le m} \overline{V}_{in}\right]\right\} \quad (6)$$

Step 8) Determining the antipattern - for a set of *m* possible alternatives A={A_1, A_2, A_3, ...A_m}, the A^{min} antipattern is defined as follows:

$$A^{min} = \{\otimes V_1^{min}, \otimes V_2^{min}, \dots, \otimes V_n^{min}\} \text{ where:}$$

$$A^{min} = \left\{\left[\min_{1 \le i \le m} \underline{V}_{i1}, \min_{1 \le i \le m} \overline{V}_{i1}\right], \left[\min_{1 \le i \le m} \underline{V}_{i2}, \min_{1 \le i \le m} \overline{V}_{i2}\right], \dots, \left[\min_{1 \le i \le m} \underline{V}_{in}, \min_{1 \le i \le m} \overline{V}_{in}\right]\right\} \quad (7)$$

Step 9) Calculation of the distance between the alternatives and the A^{max} pattern and the A^{min} anti-pattern using the formulas:

$$d_i^+ = \sum_{j=1}^{n} d\left(V_{ij}, V_j^{max}\right), \text{and } d_i^- = \sum_{j=1}^{n} d\left(V_{ij}, V_j^{min}\right) \quad for\ i = 1, 2, \dots m \quad (8)$$

$$\text{where: } d(\otimes V_A, \otimes V_B) = \sqrt{½\left[\left(\underline{V}_A - \underline{V}_B\right)^2 + \left(\overline{V}_A - \overline{V}_B\right)^2\right]}, \quad (9)$$

Step 10) Calculating the value of the synthetic rating metric for individual CC_i variants using the relative distance of the ratings of these variants to the pattern and anti-pattern:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, i = 1, 2, \dots m \quad (10)$$

The smaller the distance between the variant evaluation and the pattern, and at the same time the greater the distance from the antipattern, the closer the metric value is to 1.

Step 11) Creating a ranking for *m* alternatives *A* based on linear descending ordering of synthetic metrics.

The criteria and their weights were established taking into account the specificity of the planned maintenance and installation works from the point of view of the main threats and causes of accidents at work. As part of structuring the problem, the following criteria were defined for assessing occupational health and safety management at potential contractors: C_1– indicator of employees working in hazardous conditions of work environment factors (per 1,000 employees, according to the Z-10 report); C_2– indicator of

occupational risk assessments carried out (in %, according to the Z-10 report); C_3– indicator of employees in hazardous conditions, in relation to whom the hazards were eliminated or reduced to a level consistent with the standard during the year (per 1,000 employees, according to the Z-10 report); C_4– organizational prevention utilization indicator (in %, according to the Z-10 report), C_5– number of benefits for work in conditions harmful and burdensome to health (according to the Z-10 report), C_6– compliance indicator of training procedures and on-the-job instructions (in %, according to the submitted procedures) and implementation of activities in six selected areas according to the checklist prepared on the basis of the safety checklist for contractors SCC 2017/version 6.0: C_7– Area: Health and safety policy, organization, top management involvement and health and safety reviews; C_8– Area: Occupational health and safety risk management; C_9– Area: Training, information, instruction and developing health and safety awareness; C_{10}– Area: Employee health protection; C_{11}– Area: Purchases, inspections of materials, devices and personal protective equipment, and C_{12}– Area: Reporting, registration and investigation of near misses.
Each area included 5 questions. A minimum of 1 and a maximum of 5 points could be obtained for a given area. After determining the evaluation criteria, possible alternative solutions A were determined based on five potential contractors A_1, A_2, A_3, A_4 and A_5 with employment ranging from 26 to 43 people.
At the problem modeling stage, four E experts (on behalf of the company: an occupational health and safety employee, a production department manager and a maintenance department manager, as well as an expert from outside the company), using a prepared expert questionnaire, first assessed the significance of criteria C_1-C_{12}, using a seven-point rating scale. from "not important" to "very important". Then, the experts assessed the values of quantitative indicators C_1-C_6. The average values of individual indicators in the industry were adopted as the assessment determinant. The next activity was to assess the level of implementation of criteria C_7-C_{12} based on completed checklists provided by each of the potential contractors A_1, A_2, A_3, A_4 and A_5. The implementation of each criterion was assessed independently of the results of the assessment of the remaining criteria, using a seven-point scale from "*totally poor*" to "*excellent*".

3. RESULTS

Table 1 lists the criteria values obtained as a result of the research.

Table 1
Criteria for assess and select a contractor in terms of occupational safety management

	Indicators						**Checklist scoring**					
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	135	71	38	36	6	65	4	4	5	3	3	5
A_2	146	63	46	49	5	85	4	5	4	3	4	3
A_3	118	43	35	28	3	55	5	3	3	5	3	4
A_4	122	52	41	41	4	65	5	3	4	5	4	3
A_5	129	60	40	31	5	50	3	4	3	3	4	5

The linguistic assessments of the importance of the criteria and the linguistic assessments of the implementation of the criteria by individual contractors were assigned appropriate grey numbers, in accordance with Table 2.

Table 2
Language ratings and their corresponding grey criteria rating values

Assessment of the importance of criteria			**Assessment of the value of criteria**		
Very low	VL	[0.0, 0.1]	Very poor	VP	[0.0, 1.0]
Low	L	[0.1, 0.3]	Poor	P	[1.0, 3.0]
Medium low	ML	[0.3, 0.4]	Medium poor	MP	[3.0, 4.0]
Medium	M	[0.4, 0.5]	Fair	F	[4.0, 5.0]
Medium high	MH	[0.5, 0.6]	Medium good	MG	[5.0, 6.0]
High	H	[0.6, 0.9]	Good	G	[6.0, 9.0]
Very high	VH	[0.9, 1.0]	Very good	VG	[9.0, 10.0]

Source: (Li et al., 2007)

Table 3 summarizes the gray ratings of the importance of individual criteria.

Table 3
List of linguistic assessments of criteria significance levels

	Linguistic assessments of criteria significance levels											
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Expert no. 1	MH	H	M	VH	M	H	VH	H	MH	MH	H	MH
Expert no. 2	M	VH	MH	H	H	MH	H	VH	MH	MH	MH	H
Expert no. 3	MH	MH	M	MH	M	VH	H	MH	VH	MH	VH	H
Expert no. 4	M	MH	H	H	M	MH	MH	MH	H	MH	VH	MH

Using formula (1), the assessments of the importance of decision criteria were aggregated and the weights of individual criteria were obtained: *w*={[0.45,0.55] [0.625,0.775] [0.475,0.625] [0.625,0.85][0.45,0.60] [0.65,0.85] [0.65,0.85] [0.625,0.775] [0.625,0.775] [0.50,0.60][0.725,0.875][0.55,0.75]}. Table 4 summarizes the linguistic assessments of the level of implementation of criteria C_1-C_{12} by individual contractors.

Table 4
List of linguistic assessments of criteria performance levels

		Linguistic assessments of criteria performance levels											
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	Expert no. 1	MP	G	MP	MP	MP	F	MG	MG	G	MP	MP	G
	Expert no. 2	F	MG	F	MP	VP	MG	F	F	MG	F	MP	MG
	Expert no. 3	MP	G	MP	F	P	F	F	MG	MG	MP	MP	G
	Expert no. 4	MP	F	P	MP	VP	F	F	F	G	MP	MP	MG
A_2	Expert no. 1	P	MG	MG	MG	F	G	MG	G	MG	F	F	F
	Expert no. 2	VP	F	G	F	MP	G	MG	G	MG	F	F	F
	Expert no. 3	P	MG	MG	MG	MP	MG	MP	MG	MG	F	F	F
	Expert no. 4	P	F	F	G	P	MG	F	MG	F	F	MG	MP
A_3	Expert no. 1	G	F	P	P	MG	MP	G	F	F	G	MP	MG
	Expert no. 2	MG	P	MP	P	MG	F	G	MP	F	G	MP	MG
	Expert no. 3	G	MP	P	MP	G	MP	MG	MP	MP	G	F	F
	Expert no. 4	G	MP	P	MP	G	P	MG	MP	MP	G	MP	F
A_4	Expert no. 1	MG	G	F	F	MG	F	G	F	G	MG	F	F
	Expert no. 2	MG	MP	MG	F	F	MG	MG	MP	MG	MG	MG	MP
	Expert no. 3	F	MP	F	MG	MG	F	F	F	MG	MG	MG	MP
	Expert no. 4	MG	MP	MP	MG	F	F	G	F	F	MG	F	MP
A_5	Expert no. 1	F	G	F	MP	F	MP	F	MG	F	F	F	G

	Expert no. 2	MP	F	MG	MP	MP	MP	MP	MG	MP	MP	F	G
	Expert no. 3	MP	MG	F	F	MP	P	MP	F	MP	F	MG	MG
	Expert no. 4	MP	F	MP	MP	P	P	MP	MG	MP	MP	F	G

Using formula (2), gray assessments of individual criteria were aggregated and output data was obtained to build a gray decision matrix in accordance with formula (3). Table 5 presents gray assessments of the level of implementation of individual criteria by potential contractors.

Table 5
List of grey assessments of criteria performance levels

	Grey assessments of criteria performance levels					
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	[3.25, 4.25]	[5.25, 7.25]	[2.75, 4.00]	[3.25, 4.25]	[1.00, 2.25]	[4.25, 5.25]
A_2	[0.75, 2.50]	[4.50, 5.50]	[5.00, 6.50]	[5.00, 6.50]	[2.75, 4.00]	[5.50, 7.50]
A_3	[5.75, 8.25]	[2.25, 3.75]	[1.50, 5.25]	[2.00, 3.50]	[5.50, 7.50]	[2.75, 4.00]
A_4	[4.75, 5.75]	[3.75, 5.25]	[4.00, 5.00]	[4.50, 5.50]	[4.50, 5.50]	[4.25, 5.25]
A_5	[3.25, 4.25]	[4.75, 6.25]	[4.00, 5.00]	[3.25, 4.25]	[2.75, 4.00]	[2.00, 3.50]
	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	[4.25, 5.25]	[4.50, 5.50]	[5.50, 7.50]	[3.25, 4.25]	[3.00, 4.00]	[5.50, 7.50]
A_2	[4.25, 5.25]	[5.50, 7.50]	[4.75, 5.75]	[4.00, 5.00]	[4.25, 5.25]	[3.75, 4.75]
A_3	[5.50, 7.50]	[3.25, 4.25]	[3.50, 4.50]	[5.50, 7.50]	[3.25, 4.25]	[4.50, 5.50]
A_4	[5.25, 7.25]	[3.75, 4.75]	[5.00, 6.50]	[5.00, 6.00]	[4.50, 5.50]	[3.25, 4.25]
A_5	[3.25, 4.25]	[4.75, 5.75]	[3.25, 4.25]	[3.50, 4.50]	[4.25, 5.25]	[5.75, 8.25]

Then, using formula (4), a standardized gray decision matrix was built (Table 6), assuming that 10 decision criteria are of a profit nature (the higher the value, the better), and 2 criteria are of a cost nature (the lower the value, the better).

Table 6
Values from the normalized grey decision-making matrix

	Normalized grey assessments of criteria performance levels					
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	[0.18, 0.23]	[0.72, 1.00]	[0.42, 0.62]	[0.50, 0.65]	[0.44, 1.00]	[0.57, 0.70]
A_2	[0.30, 1.00]	[0.62, 0.76]	[0.77, 1.00]	[0.77, 1.00]	[0.25, 0.36]	[0.73, 1.00]
A_3	[0.09, 0.13]	[0.31, 0.52]	[0.23, 0.81]	[0.31, 0.54]	[0.13, 0.18]	[0.37, 0.53]
A_4	[0.13, 0.16]	[0.52, 0.72]	[0.62, 0.77]	[0.69, 0.85]	[0.18, 0.22]	[0.57, 0.70]
A_5	[0.18, 0.23]	[0.66, 0.86]	[0.62, 0.77]	[0.50, 0.65]	[0.25, 0.36]	[0.27, 0.47]
	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	[0.57, 0.70]	[0.60, 0.73]	[0.73, 1.00]	[0.43, 0.57]	[0.55, 0.73]	[0.67, 0.91]
A_2	[0.57, 0.70]	[0.73, 1.00]	[0.63, 0.77]	[0.53, 0.67]	[0.77, 0.95]	[0.45, 0.58]
A_3	[0.73, 1.00]	[0.43, 0.57]	[0.47, 0.60]	[0.73, 1.00]	[0.59, 0.77]	[0.55, 0.67]
A_4	[0.70, 0.97]	[0.50, 0.63]	[0.67, 0.87]	[0.67, 0.80]	[0.82, 1.00]	[0.39, 0.52]
A_5	[0.43, 0.57]	[0.63, 0.77]	[0.43, 0.57]	[0.47, 0.60]	[0.77, 0.95]	[0.70, 1.00]

Based on the data from the grey normalized decision matrix and the calculated weights of individual criteria, a weighted normalized decision matrix was built using formula (5). Table 7 summarizes the values from the weighted normalized decision matrix.

Table 7
Values from the weighted normalized grey decision-making matrix

	Weighted normalized grey assessments of criteria performance levels					
	C_1	C_2	C_3	C_4	C_5	C_6
A_1	[0.08, 0.13]	[0.45, 0.78]	[0.20, 0.38]	[0.31, 0.56]	[0.20, 0.60]	[0.37, 0.60]
A_2	[0.14, 0.55]	[0.39, 0.59]	[0.37, 0.63]	[0.48, 0.85]	[0.11, 0.22]	[0.48, 0.85]
A_3	[0.04, 0.07]	[0.19, 0.40]	[0.11, 0.50]	[0.19, 0.46]	[0.06, 0.11]	[0.24, 0.45]
A_4	[0.06, 0.09]	[0.32, 0.56]	[0.29, 0.48]	[0.43, 0.72]	[0.08, 0.13]	[0.37, 0.60]
A_5	[0.08, 0.13]	[0.41, 0.67]	[0.29, 0.48]	[0.31, 0.56]	[0.11, 0.22]	[0.17, 0.40]
	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	[0.37, 0.60]	[0.38, 0.57]	[0.46, 0.78]	[0.22, 0.34]	[0.40, 0.64]	[0.37, 0.68]
A_2	[0.37, 0.60]	[0.46, 0.78]	[0.40, 0.59]	[0.27, 0.40]	[0.56, 0.84]	[0.25, 0.43]
A_3	[0.48, 0.85]	[0.27, 0.44]	[0.29, 0.47]	[0.37, 0.60]	[0.43, 0.68]	[0.30, 0.50]
A_4	[0.46, 0.82]	[0.31, 0.49]	[0.42, 0.67]	[0.33, 0.48]	[0.60, 0.88]	[0.22, 0.39]
A_5	[0.28, 0.48]	[0.40, 0.59]	[0.27, 0.44]	[0.23, 0.36]	[0.56, 0.84]	[0.38, 0.75]

Data from the weighted normalized decision matrix were used to identify the ideal solution - pattern according to formula (6) and the anti-ideal solution - anti-pattern, according to formula (7). The ideal solution is: A^{max} ={[0.14,0.55] [0.45,0.78] [0.37,0.63] [0.48,0.85] [0.20,0.60] [0.48,0.85] [0.48,0.85] [0.46,0.78] [0.46,0.78] [0.37,0.60] [0.60,0.88] [0.38,0.75]}, while the anti-ideal solution is: A^{min} ={[0.04,0.07] [0.19,0.40] [0.11,0.50] [0.19,0.46] [0.11,0.22] [0.17,0.40] [0.28,0.48] [0.27,0.44] [0.27,0.44] [0.22,0.34] [0.40,0.64] [0.22,0.39]}.
Based on the established pattern and antipattern, the distances of individual alternatives A1-A5 were calculated using formulas (8) and (9). The calculated distances d+ and d- are listed in Table 8.

Table 8
List of distances of the alternatives A from the pattern and the anti-pattern

	List of distances											
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
	d+											
A_1	0.302	0.000	0.206	0.240	0.000	0.196	0.196	0.157	0.000	0.212	0.220	0.050
A_2	0.000	0.140	0.000	0.000	0.277	0.000	0.196	0.000	0.135	0.158	0.040	0.244
A_3	0.345	0.322	0.200	0.344	0.361	0.327	0.000	0.272	0.249	0,000	0.185	0.186
A_4	0.332	0.177	0.114	0.099	0.340	0.196	0.025	0.226	0.079	0.088	0.000	0.283
A_5	0.302	0.082	0.114	0.240	0.277	0.386	0.295	0.135	0.272	0.194	0.040	0.000
	d-											
A_1	0.047	0.322	0.107	0.110	0.277	0.197	0.101	0.117	0.272	0.000	0.000	0.234
A_2	0.344	0.190	0.200	0.344	0.000	0.386	0.101	0.272	0.141	0.055	0.181	0.040
A_3	0.000	0.000	0.000	0.000	0.086	0.061	0.294	0.000	0.023	0.212	0.035	0.100
A_4	0.016	0.146	0.130	0.251	0.064	0.197	0.270	0.047	0.194	0.129	0.220	0.000
A_5	0.047	0.243	0.130	0.110	0.000	0.000	0.000	0.141	0.000	0.018	0.181	0.283

Based on the distances from Table 8, synthetic measures of evaluation of individual alternatives were determined using formula (10). Then a ranking of alternatives was created in descending order: $CC(A_2)=0.654$, $CC(A_1)=0.501$, $CC(A_4)=0.459$, $CC(A_5)=0.331$ and $CC(A_3)=0.226$.

4. DISCUSSION

According to the interpretation of the CC_i synthetic meter, it should be concluded that with such adopted assessment criteria and their significance determined in this way, the potential A_2 contractor meets the assumed occupational health and safety management criteria to the greatest extent. However, the potential contractor A_3 meets these criteria the least.
The first problem in the discussion is the criteria for selecting contractors. They depend to a large extent on the individual strategy of the company - the decision-maker. There is no single set of criteria in the literature that can be used in every case. Identifying selection criteria in many cases requires appropriate expert knowledge and the ability to properly assess them. Therefore, it would be necessary to consider using a different approach to determining the significance of individual assessment criteria, in such a way as to take into account the varied impact of individual criteria on the achievement of the main goal, i.e. ensuring safe performance of work.
The second significant problem in the discussion is the adopted method of aggregating expert assessments, which assumes that all experts have equal knowledge and competences in the analyzed area. And in this case, possible differentiation of the weight of assessments should be considered, especially in a situation where there are no uniform guidelines for the selection of experts.

5. CONCLUSION

The aim of this article is to analyze the possibility of using the gray TOPSIS method to assess, compare and identify five potential contractors from the point of view of 12 criteria related to occupational health and safety management.
The work is original. In the area of occupational health and safety management, there is a lack of practically verified tools that decision-makers could use in the decision-making process regarding ensuring occupational safety, especially in the case of selection using various criteria. Therefore, it seems justified to take actions and conduct research that can change this.
Moreover, comparison and evaluation between contractors of activities carried out in the field of occupational safety management may be an important source of information for decision-makers on what should be improved in the processes implemented in this area. The approach used in this work is relatively simple, and any spreadsheet can be used to carry out the mathematical operations. The presented research and analyzes confirmed the usefulness of the gray TOPSIS method in the area of occupational health and safety, for assessing, comparing and identifying contractors who best and worst fulfill the adopted criteria for assessing occupational health and safety management. The gray TOPSIS method is an appropriate tool for conducting contractor selection and provides strong references for ranking potential contractors. At the same time, the method used can improve the quality of decisions made by making the decision-making process more rational and effective. Moreover, the work may be an inspiration to look for other applications of the gray TOPSIS method, both in the area of occupational health and safety management, and towards the use of gray numbers in other multi-criteria decision-making methods. Therefore, further work is planned on the practical verification of the suitability of various MCDM methods for solving key problems in the area of occupational health and safety management.

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