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OCCUPATIONAL HAZARDS MANAGEMENT USING A GREY-BASED DECISION-MAKING APPROACH

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Abstract: The objective of this paper is to present and verify the decision-making model which makes it possible to streamline the occupational hazards that tend to occur in the work environment, according to the adopted decision-making criteria. In this way, it will be possible to reduce inconsistencies of decision-makers deciding to focus their preventive measures upon the most important hazards, in the situation when the same assessments for hazards are obtained using classical matrix techniques. Within this model, a grey approach was proposed, which makes it possible for experts to use linguistic variables in such assessments. The following three risk assessment parameters were used as the criteria: probability of occurrence of hazards, level of their consequences, and a possibility to avoid them. The model was verified in a furniture manufacturing company on the basis of 17 key hazards assessment, which had been carried out by: an executive officer, a direct supervision employee, a work health and safety officer, and an expert coming from outside the company. This paper remedies some shortcomings in using the grey theory in occupational risk management, and constitutes an original application of this concept in the work safety area.
Keywords: risk management, occupational safety, MCDM, enterprise, Grey theory

1. INTRODUCTION

Risk management is the key process within the framework of providing safe conditions of work (Holubová, 2016). Assessment of the hazards that tend to occur in the work environment constitutes the basic measure in this area, which is confirmed by numerous risk and work safety management analysis and assessment models discussed in the literature of the subject (e.g. IEC/ISO 31010:2009). This model proposes the grey approach which makes it possible for experts to use linguistic variables. The Grey Systems Theory (GST) is the latest methodology (although its origins go back to 1982) of analysing and assessing systems in the situation when information concerning these systems is uncertain or incomplete (Deng, 1982). The Grey Systems Theory allows us to bypass many necessary assumptions concerning statistical methods, fuzzy or rough, so that the results obtained using grey numbers are much more accurate than in other approaches (Liu et al., 2016). Let X be the universal set. Then a grey set G of X is defined by two mappings $\overline{\mu}_G(X)$ and $\underline{\mu}_G(X)$: $\overline{\mu}_G(X): X \rightarrow [0,1]$ and $\underline{\mu}_G(X): X \rightarrow [0,1]$ such that $\overline{\mu}_G(X) \geq \underline{\mu}_G(X), x \in X$. Since the lower limit $\otimes G = [\underline{G}, \infty)$ and upper limit $\otimes G = (-\infty, \overline{G}]$ can be estimated, G is defined as interval grey number $\otimes G = [\underline{G}, \overline{G}]$. The basic operations on grey numbers are performed in the following manner:

$\otimes G_1 + \otimes G_2 = [\underline{G_1} + \underline{G_2}, \overline{G}_1 + \overline{G}_2]$; $\otimes G_1 - \otimes G_2 = [\underline{G_1} - \overline{G}_2, \overline{G}_1 - \underline{G_2}]$

$\otimes G_1 \times \otimes G_2 = [\min(\underline{G_1}\underline{G_2}, \underline{G_1}\overline{G}_2, \overline{G}_1\underline{G_2}, \overline{G}_1\overline{G}_2), \max(\underline{G_1}\underline{G_2}, \underline{G_1}\overline{G}_2, \overline{G}_1\underline{G_2}, \overline{G}_1\overline{G}_2)]$

$\otimes G_1 \div \otimes G_2 = [\underline{G_1}, \overline{G}_1] \times \left[\frac{1}{\underline{G_2}}, \frac{1}{\overline{G}_2}\right]$. On the other hand, the comparison of gray numbers follows the formula:

$P\{\otimes G_1 \leq \otimes G_2\} = \frac{max(0, L^* - \max(0, \overline{G}_1 - \underline{G_2}))}{L^*}, where\ L^* = L(\otimes G_1) + L(\otimes G_2)$, and L is the length of a grey number: $L(\otimes G) = [\overline{G} - \underline{G}]$.

As a result of comparison of two grey numbers, three special cases are possible:

- $If\ \underline{G_1} = \underline{G_2}\ and\ \overline{G}_1 = \overline{G}_2\ that \otimes G_1 = \otimes G_2, then\ P\{\otimes G_1 \leq \otimes G_2\} = 0.5,$
- $If\ \underline{G_2} > \overline{G}_1\ that \otimes G_2 is\ larger\ than\ \otimes G_1, then\ P\{\otimes G_1 \leq \otimes G_2\} = 1,$
- $If\ \overline{G}_2 < \underline{G_1} that \otimes G_2 is\ smaller\ than \otimes G_1, then\ P\{\otimes G_1 \leq \otimes G_2\} = 0.$

The Grey Systems Theory finds its applications in many disciplines of engineering/ technological, medical and social sciences, which is confirmed by the exponentially growing number of publications concerning its applications in practice, including in broadly comprehended safety engineering and in management of economic systems in differing scales. One of its fastest-growing applications is using GST in both classical and modern tools of the multi-criterion decision-making process (Tzeng and Huang, 2011).

The objective of this paper is to present and verify the decision-making model used to streamline the hazards that tend to occur in the work environment, according to criteria adopted by decision-makers. In this way, it will be possible to reduce inconsistencies of decision-makers deciding to focus their preventive measures upon the most important hazards, in the situation when the same assessments for hazards are obtained using classical matrix techniques.

2. METHODOLOGY OF RESEARCH

The model makes use of the concept of distance from the ideal alternative, coupled with the operation of comparing grey numbers with the ideal alternative's special cases. The hazard-ranking procedure consists of the following stages.

1) Assessing decision-making criteria using linguistic variables.

2) Determining significance levels of the decision-making criteria, and aggregating these assessments using a selected method (e.g. the arithmetic mean method):

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

3) Assessing alternatives using linguistic variables, and aggregating these assessments using a selected method (e.g. the arithmetic mean method):

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

Where:

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

4) Constructing a grey decision-making matrix for the given form:

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

5) Constructing a normalized grey decision-making matrix for the given form:

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

For the cost-type criterion (the lower the value, the better), normalisation takes place according to formula (5):

$$\otimes G_{ij}^{*} = \left[\frac{G_{j}^{min}}{\overline{G}_{ij}}, \frac{G_{j}^{min}}{\underline{G}_{ij}}\right], where: G_{j}^{min} = \min_{1 \le i \le m}\{\underline{G}_{ij}\}; \tag{5}$$

and in case of the profit-type criterion (the higher the value, the better), according to the following formula (6):

$$\otimes G_{ij}^{*} = \left[\frac{\underline{G}_{ij}}{G_{j}^{max}}, \frac{\overline{G}_{ij}}{G_{j}^{max}}\right], where: G_{j}^{max} = \min_{1 \le i \le m}\{\overline{G}_{ij}\} \tag{6}$$

6) Constructing a weighted normalized grey decision-making matrix for the given form:

$$D_{W}^{*} = \begin{bmatrix} \otimes V_{11} & \otimes V_{12} & \cdots & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & & \otimes V_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \otimes V_{m1} & \otimes V_{m2} & \cdots & \otimes V_{mn} \end{bmatrix}, where: \otimes V_{ij} = \otimes G_{ij}^{*} \times \otimes W_{j} \tag{7}$$

7) Identifying the best alternative according to the below assumption that for the *m* set of possible alternatives $A = \{A_1, A_2, A_3, \ldots, A_m\}$, the ideal alternative A^{max} is determined as follows:

$$A^{max} = \{\otimes G_{1}^{max}, \otimes G_{2}^{max}, \ldots, \otimes G_{n}^{max}\} \tag{8}$$

where $A^{max} = \left\{\left[\max_{1 \le i \le m} \underline{V}_{i1}, \max_{1 \le i \le m} \overline{V}_{i1}\right], \left[\max_{1 \le i \le m} \underline{V}_{i2}, \max_{1 \le i \le m} \overline{V}_{i2}\right], \ldots, \left[\max_{1 \le i \le m} \underline{V}_{in}, \max_{1 \le i \le m} \overline{V}_{in}\right]\right\}$

8) Calculating the possibility degree of the compared alternatives *A* and the ideal alternative A^{max}, using the following formula:

$$P\{A_i \leq A^{max}\} = \frac{1}{n}\sum_{j=1}^{n} P\{\otimes V_{ij\leq} \otimes G_j^{max}\} \quad (9)$$

9) Sorting the obtained *P* values, and thereby *A* alternatives, in the increasing order.

The adopted model was verified in a middle-sized furniture manufacturing company, from the standpoint of the nature and diversity of the hazards that tend to occur in companies from this sector. Four evaluators, such as: an executive officer (EMP), a direct supervision employee (SUP), an occupational health and safety management officer (OHSM), and an expert coming from outside the company (EXP) were asked to assess the following 3 decision-making criteria: probability of occurrence (L), level of consequences (S), and a possibility to avoid losses (prevention) (P), as well as 17 basic hazards identified upon the basis of analysis of the incidents/ accidents record and occupational risk assessment sheets at the particular work stands in the company under review. These 17 alternatives (hazards) were, respectively: H1- contact with electricity through a direct touch, H2- explosion, H3- flame, H4- ignition of flammable materials, H5- gas and vapour emissions, H6- dust and smoke emissions, H7- contact with chemicals, H8- getting hit by a falling object, H9- getting hit by an object thrown out of the machine, H10- getting hit by a an object that moves horizontally, H11- contact with a sharp object, H12- contact with a hot object, H13- entrapment, crushing, H14- excessive strain on the musculoskeletal system, H15- environmental impacts of noise above 80 decibels, H16- stumbling, skidding, and H17- fall from height. To assess significance criteria, the evaluators used a previously prepared seven-grade linguistic assessment scale ranging from *non-significant* to *highly significant*. Linguistic assessments were assigned their corresponding grey numbers with the following values: *non-significant* [0.0, 0.1], *low* [0.1, 0.3], *medium-low* [0.3, 0.4], *medium* [0.4, 0.5], *medium-significant* [0.5, 0.6], *significant* [0.6, 0.9] and *highly significant* [0.9, 1.0]. On the other hand, the particular alternatives (hazards) were assessed for each criterion (L, S, and P), using the three linguistic scales that are described in Table 1, together with their corresponding grey numbers.

Table 1
List of linguistic assessment scales used to assess the criteria

Seven-grade Linguistic Assessment Scales			**Grey Numbers**
Probability (L)	**Level of Consequences (S)**	**Prevention (P)**	
Unbelievable	Incident without consequences	Evident	[0.0, 1.0]
Unlikely	A slight injury, little material damage on the premises of the company	Very easy to implement	[1.0, 3.0]
Ad hoc	Light injury, medium material damage	Quite easy to implement	[3.0, 4.0]
Quite frequent	Medium damage, measurable damage on the company premises	It is possible to implement	[4.0, 5.0]
Frequent	Severe injuries, serious damage on the premises of the company	Difficult to implement	[5.0, 6.0]
Very often	A single fatal accident, big damage on the premises of the company	Very difficult to implement	[6.0, 9.0]

Almost certain	Collective fatal accident, big damage even outside the company	Impossible	[9.0, 10.0]

The first two criteria, i.e. probability and the level of consequences, serve as a basis for all the classical matrix risk assessment methods, whereas the criterion of the possibility to avoid loss (prevention) occurs e.g. in the JSA method (Main, 2012; Rausand, 2013). Risk assessment methods differ not only in the number of parameters involved but also in their level of detail (Marhavilas et al., 2011; Tixier et al., 2002). Within the approach as discussed above, seven assessment grades of parameters L, S, and P correspond to seven grey numbers.

3. RESULTS

Upon completion of the above-described procedure, in the first sequence, experts EMP, SUP, OHSM, and EXP contributed their linguistic assessments of significance of the three analysed criteria L, S, and P. These linguistic assessments were then assigned their corresponding grey numbers. Table 2 lists grey assessments of the criteria, as well as the single aggregated assessment obtained by using formula (1) that pertains to the aggregation process using the adopted arithmetic mean method.

Table 2
List of grey assessments of significance of the criteria L, S, and P

	EMP	**SUP**	**OHSM**	**EXP**	**Aggregated Assessments**
L	[0.4, 0.5]	[0.4, 0.5]	[0.9, 1.0]	[0.5, 0.6]	[0.55, 0.65]
S	[0.9, 1.0]	[0.6, 0.9]	[0.4, 0.5]	[0.6, 0.9]	[0.63, 0.82]
P	[0.6, 0.9]	[0.5, 0.6]	[0.6, 0.9]	[0.9, 1.0]	[0.65, 0.85]

Then, linguistic assessments of the particular *H* alternatives H1-H17, as performed by the experts, were assigned their corresponding grey numbers in line with Table 1. As a result of aggregation of assessments of the particular alternatives according to formula (2), input data were obtained and used to construct the grey decision-making matrix according to formula (3) – Table 3. The ranking of linguistic assessments for criteria L, S, and P in Table 3 pertains, successively, to the indications received from EMP, SUP, OHSM, and EXP.

Table 3
Linguistic and grey hazard assessments breakdown by the criteria L, S, and P

A	**Linguistic Assessments**			**Aggregated Grey Assessments**		
	L	**S**	**P**	**L**	**S**	**P**
H1	L4,L2,L3,L3	S5,S5,S7,S6	P3,P2,P3,P2	[2.75, 4.00]	[6.25, 7.75]	[2.00, 3.50]
H2	L2,L1,L3,L6	S6,S6,S7,S7	P5,P3,P5,P4	[2.50, 4.25]	[7.50, 9.50]	[4.25, 5.25]
H3	L3,L2,L2,L3	S4,S4,S5,S5	P2,P3,P4,P3	[2.00, 3.50]	[4.00, 5.00]	[2.75, 4.00]
H4	L3,L5,L5,L6	S2,S3,S5,S7	P5,P4,P5,P4	[4.75, 6.25]	[4.50, 5.75]	[4.50, 5.50]
H5	L3,L5,L5,L6	S3,S3,S4,S5	P2,P3,P3,P2	[4.75, 6.25]	[3.75, 4.75]	[2.00, 3.50]
H6	L5,L3,L3,L4	S4,S3,S3,S5	P2,P3,P3,P2	[3.75, 4.75]	[3.75, 4.75]	[2.00, 3.50]
H7	L3,L4,L3,L5	S4,S3,S5,S5	P4,P3,P3,P3	[3.75, 4.75]	[4.25, 5.25]	[3.25, 4.25]
H8	L2,L3,L2,L3	S5,S5,S6,S6	P3,P3,P3,P2	[2.00, 3.50]	[5.50, 7.50]	[2.50, 3.75]
H9	L4,L2,L3,L2	S5,S4,S5,S4	P3,P4,P4,P3	[2.25, 3.75]	[4.50, 5.50]	[3.50, 4.50]
H10	L3,L2,L2,L3	S5,S4,S4,S5	P5,P4,P3,P4	[2.00, 3.50]	[4.50, 5.50]	[4.00, 5.00]
H11	L5,L5,L6,L7	S3,S3,S4,S5	P5,P4,P3,P3	[6.25, 7.75]	[3,75, 4.75]	[3.75, 4.75]

H12	L2,L2,L2,L3	S3,S4,S4,S5	P3,P3,P4,P2	[1.50, 3.25]	[4.00, 5.00]	[2.75, 4.00]
H13	L2,L2,L3,L3	S5,S6,S6,S5	P2,P4,P3,P5	[2.00, 3.50]	[5.50, 7.50]	[3.25, 4.50]
H14	L4,L4,L5,L5	S4,S3,S4,S5	P5,P4,P3,P4	[4.50, 5.50]	[4.00, 5.00]	[4.00, 5.00]
H15	L5,L4,L4,L6	S2,S2,S3,S3	P4,P3,P3,P2	[4.75, 6.25]	[2.00, 3.50]	[2.75, 4.00]
H16	L5,L5,L6,L6	S2,S2,S3,S3	P2,P3,P2,P3	[5.50, 7.50]	[2.00, 3.50]	[2.00, 3.50]
H17	L2,L3,L3,L2	S4,S5,S4,S5	P2,P3,P3,P2	[2.00, 3.50]	[4.50, 5.50]	[2.00, 3.50]

Assuming, in the former case, that the adopted criteria were cost-type criteria, values occurring in the grey decision-making matrix were normalized using formula (5), and data were obtained and used to construct the first normalized grey decision-making matrix; and then, by using formula (7), values were obtained for the weighted normalised grey decision-making matrix. In the latter case, the above-mentioned operations were repeated, assuming that the decision-making criteria were profit-type criteria, and data were obtained and used to construct the second normalised grey decision-making matrix, and then, after using formula (7), to construct the second weighted normalized grey decision-making matrix. Table 4 lists values of weighted normalized decision-making matrices for both types of criteria.

Table 4

List of values of weighted normalised grey decision-making matrices in case cost-type criteria and profit-type criteria are adopted

A	**Cost-type Criteria (C)**			**Profit-type Criteria (B)**		
	L	**S**	**P**	**L**	**S**	**P**
H1	[0.21, 0.36]	[0.16, 0.26]	[0.37, 0.85]	[0.20, 0.34]	[0.42, 0.67]	[0.24, 0.54]
H2	[0.19, 0.39]	[0.13, 0.22]	[0.25, 0.40]	[0.18, 0.36]	[0.50, 0.82]	[0.50, 0.81]
H3	[0.24, 0.49]	[0.25, 0.41]	[0.33, 0.62]	[0.14, 0.29]	[0.27, 0.43]	[0.33, 0.62]
H4	[0.13, 0.21]	[0.22, 0.36]	[0.24, 0.38]	[0.34, 0.52]	[0.30, 0.50]	[0.53, 0.85]
H5	[0.13, 0.21]	[0.27, 0.44]	[0.37, 0.85]	[0.34, 0.52]	[0.25, 0.41]	[0.24, 0.54]
H6	[0.18, 0.26]	[0.27, 0.44]	[0.37, 0.85]	[0.27, 0.40]	[0.25, 0.41]	[0.24, 0.54]
H7	[0.18, 0.26]	[0.24, 0.39]	[0.31, 0.52]	[0.27, 0.40]	[0.28, 0.45]	[0.38, 0.66]
H8	[0.24, 0.49]	[0.17, 0.30]	[0.35, 0.68]	[0.14, 0.29]	[0.36, 0.65]	[0.30, 0.58]
H9	[0.22, 0.43]	[0.23, 0.36]	[0.29, 0.49]	[0.16, 0.31]	[0.30, 0.47]	[0.41, 0.70]
H10	[0.24, 0.49]	[0.23, 0.36]	[0.26, 0.43]	[0.14, 0.29]	[0.30, 0.47]	[0.47, 0.77]
H11	[0.11, 0.16]	[0.27, 0.44]	[0.27, 0.45]	[0.44, 0.65]	[0.25, 0.41]	[0.44, 0.73]
H12	[0.25, 0.65]	[0.25, 0.41]	[0.33, 0.62]	[0.11, 0.27]	[0.27, 0.43]	[0.33, 0.62]
H13	[0.24, 0.49]	[0.17, 0.30]	[0.29, 0.52]	[0.14, 0.29]	[0.36, 0.65]	[0.38, 0.70]
H14	[0.15, 0.22]	[0.25, 0.41]	[0.26, 0.43]	[0.32, 0.46]	[0.27, 0.43]	[0.47, 0.77]
H15	[0.13, 0.21]	[0.36, 0.82]	[0.33, 0.62]	[0.34, 0.52]	[0.13, 0.30]	[0.33, 0.62]
H16	[0.11, 0.18]	[0.36, 0.82]	[0.37, 0.85]	[0.39, 0.63]	[0.13, 0.30]	[0.24, 0.54]
H17	[0.24, 0.49]	[0.23, 0.36]	[0.37, 0.85]	[0.14, 0.29]	[0.30, 0.47]	[0.24, 0.54]

According to formula (8), the ideal alternative, in case cost-type criteria (C) are adopted is: [0.25, 0.65] [0.36, 0.82] [0.37, 0.85], whereas, in case profit-type criteria (B) are adopted, the ideal alternative is: [0.44, 0.65] [0.50, 0.82] [0.53, 0.85]. Using the principle of comparing two grey numbers and formula (9), a list of *P* values was obtained for the two cases of interpretation of the decision-making criteria: the cost-type criterion (C), and the profit-type criterion (B) – Table 5.

Table 5
Possibility degree of the compared alternatives and the ideal alternative

A	Cost-type Criteria			Profit-type Criteria			$P\{A_i \leq A^{max}\}$	
	L	S	P	L	S	P	C	B
H1	0.81	1.00	0.50	1.00	0.71	0.98	0.77	0.90
H2	0.77	1.00	0.95	1.00	0.50	0.55	0.91	0.68
H3	0.63	0.92	0.68	1.00	1.00	0.86	0.74	0.95
H4	1.00	1.00	0.98	0,78	1.00	0.50	0.99	0.76
H5	1.00	0.87	0.50	0.78	1.00	0.98	0.79	0.92
H6	0.98	0.87	0.50	1.00	1.00	0.98	0.78	0.99
H7	0.98	0.95	0.78	1.00	1.00	0.79	0.90	0.93
H8	0.63	1.00	0.62	1.00	0.79	0.92	0.75	0.89
H9	0.70	1.00	0.82	1.00	1.00	0.73	0.84	0.91
H10	0.63	1.00	0.91	1.00	1.00	0.61	0.85	0.87
H11	1.00	0.87	0.88	0.50	1.00	0.67	0.92	0.72
H12	0.50	0.92	0.68	1.00	1.00	0.86	0.70	0.95
H13	0.63	1.00	0.79	1.00	0.76	0.74	0.81	0.83
H14	1.00	0.92	0.91	0.94	1.00	0.61	0.94	0.85
H15	1.00	0.50	0.68	0.78	1.00	0.86	0.72	0.88
H16	1.00	0.50	0.50	0.58	1.00	0.98	0.67	0.85
H17	0.63	1.00	0.50	1.00	1.00	0.98	0.71	0.99

After sorting the obtained *P* values, and thereby *H* alternatives, in the increasing order (step 9 of the procedure), in case cost-type criteria were adopted (the fewer, the better), a hierarchy of hazards was obtained in the following form:

$$H_{16} > H_{12} > H_{17} > H_{15} > H_3 > H_8 > H_1 > H_6 > H_5 > H_{13} > H_9 > H_{10} > H_7 > H_2 > H_{11} > H_{14} > H_4$$

On the other hand, in case profit-type criteria were adopted (the more, the better), the sequence of hazards appeared as follows:

$$H_{16} > H_{12} > H_{17} > H_{15} > H_3 > H_8 > H_1 > H_6 > H_5 > H_{13} > H_9 > H_{10} > H_7 > H_2 > H_{11} > H_{14} > H_4$$

4. DISCUSSION

In this approach, the arithmetic mean method was used to aggregate assessments, but it is also possible to use another, simpler aggregation process, e.g. using the weighted average method, which makes it possible to assign different weights to assessments received from the particular experts (e.g. to assign the highest weight to the assessment made by the expert from outside the company, or to assign the highest weight to the criterion of the possibility to avoid preventive measures). It is also important to clearly determine the nature of the criteria (the cost-type criterion only, the profit-type criterion only, or the mixed arrangement). To clearly determine the purpose of the obtained hierarchy of hazards, as the streamlining process with the assumption that the criteria are profit-type criteria is not merely a straightforward reversal of the streamlining process when the criteria are cost-type criteria. In case it is assumed that the assessment criteria are cost-type criteria (C), which translates into assessment in the direction: improbable, with no consequences, and preventive measures are obvious, the most significant hazards are, successively: stumbling, skidding (H16), contact with a hot object (H12), and a fall from height (H17). On the other hand, in case the assessment criteria are profit-type criteria (B), it translates into assessment in the direction: almost certain, fatal accident involving a number of persons, and preventive measures are not possible, the most important hazards include: explosion (H2), contact with a sharp object (H11), and ignition of flammable materials (H4).

5. CONCLUSION

This paper proposes the methodology of grey multi-criterion assessment of hazards, which makes it possible for experts to use linguistic variables in order to assess the three basic criteria: probability, level of consequences, and the possibility to avoid losses, and then to streamline the hazards that tend to occur in the work environment according to predetermined needs. By applying the model presented herein, it was possible to streamline the occupational hazards assessed using the adopted assessment criteria, with two different assumptions as to the nature of these criteria. The practical application of the approach as presented above makes it possible to reduce any inconsistencies in decisions made by decision-makers. The decision-makers are thereby able focus their preventive measures upon hazards that are significant from their own point of view, in situations when such hazards are ranked identically using the most frequently used matrix methods. This paper constitutes an original application of the GST concept in the selected occupational risk management area, and remedies some shortcomings that occur when applying this theory to work safety management systems. To sum up, further research work should be conducted with the aim to develop some new hybrid, multi-criterion assessment methods, which will consolidate the well-known multi-criterion decision-making methods (e.g. AHP, TOPSIS) within the frameworks of the Grey Systems Theory, in order to make it possible for various parties involved to wage a more effective fight against hazards not only in the furniture industry but also in other manufacturing sectors.

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