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EXPERT AND CLUSTERING METHOD OF QUALITY EVALUATION OF WORKING CONDITIONS

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The aim of the article is to present the author's original method for evaluating the quality of working conditions. The concept of the method is based on the use of expert assessment and applying a classification algorithm deriving from grey systems theory. At the theoretical level, the elaborated method draws on the praxeological approach to work as a specific activity, as well as on the qualitative approach.

Keywords: quality, working conditions, grey systems theory.

1. INTRODUCTION

The preliminary postulate in designing the expert and cluster method for evaluating the quality of working conditions was adopting the following assumptions:

- work is a particular form of activity, therefore it has been intentional to apply praxeological approach to analyse it,
- working conditions are defined as the elements necessary for work, understood as the activity together with its environment, to occur,
- systematisation of qualitative representation of the working conditions' quality is accomplished by identifying the set of elements constituting them. In accordance with the praxeological approach, this set comprises: the subject, tools, material, methods and environment of work;
- the fundamental category underlying the process of quality management of working conditions is their valuated quality,
- valuation of working conditions' quality has to account for the praxeological and ergonomic criteria,
- the set of ergonomic criteria concerning the valuation of working conditions'

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quality includes the following: occupational safety, understood as the degree to which the given working conditions have an effect on the incidence of unexpected occurrences and accidents; harmfulness of work environment, understood as the degree to which working conditions influence the development of occupational and paraoccupational diseases; finally, onerous work environment, understood as the degree to which working conditions reduce the comfort of work. Correspondingly, the set of praxeological criteria incorporates work effectiveness, understood as the degree to which work objectives are achieved for the given workstand, as well as work efficiency, defined as the relation of expenditures to the attained effects,

- the method ought to account for the fact that particular valuation criteria may have different priority for the managers,
- the method of valuating the quality of working conditions ought to be based on an algorithm allowing to categorize the identified characteristics of working conditions to the appropriate classification group¹, for which suitable managerial actions should be specified in advance,
- a classification algorithm used for categorising the characteristics of working conditions to the appropriate groups with Grey Clustering Analysis,
- the use of Grey Clustering Analysis for quality evaluation of working conditions is justified by the fact that each method of Grey Systems Theory can operate on uncertain data, especially determined on an ordinal scale, which is extremely important in the case of expert judgment (Liu, Forest, 2010),
- the variety, complexity and multilateral character of working conditions results in that the valuation of their quality has to be conducted with the aid of expert judgment,
- since the obtained information in the quantified form, on the basis of expert judgement, is subject to a large degree of uncertainty, it is justified to apply methods allowing to model this kind of numerical data (Liu, Forrest, 2010; Thurston, 1927).

The assumptions presented above have been employed as the theoretical framework for designing particular solutions in the method.

2. GENERAL SCHEME OF CONDUCT IN THE METHOD

Methodical approach, within the context of any issue under discussion, ought to be characterised by rationality, orderliness, recurrence of conduct, purposefulness, organisation, and planned selection of resources (Szafranski, 2006). The applica-

¹ Because of the fact that the crucial elements of the method are both the modified algorithm of grey cluster analysis and expert judgment as the basis for the assessment of the state of features, the Author decided to label it the expert and clustering method.

tion of such an approach for the questions related to evaluation of working conditions' quality reduces the probability of overseeing, in the practice of managerial activity, the significant issues affecting working conditions' ergonomics (and especially occupational safety and harmfulness), as well as effectiveness and efficiency of the process of completing the tasks by particular workstands. General standards of conduct in the method have been visually presented in fig. 1.

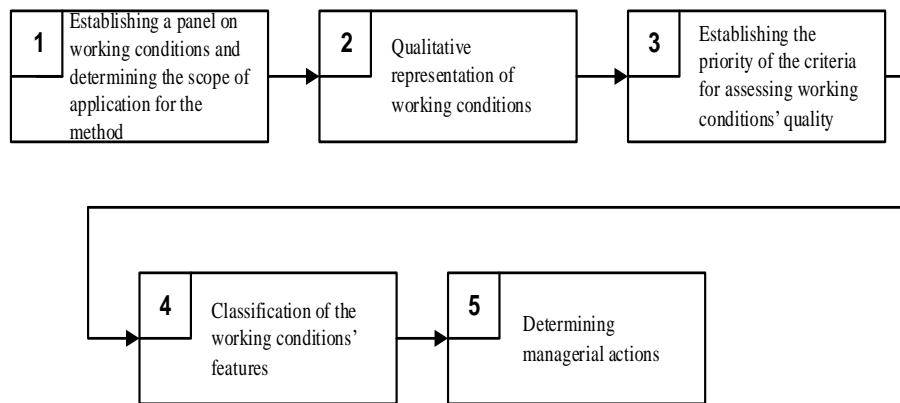


Fig. 1. General standards of conduct in the method (author's own elaboration)

Ad. 1. Establishing an assessment panel and determining the scope of application for the method is a stage whose aim is to appoint the individuals engaged in the methodical approach to labour quality evaluation and defining their responsibilities and powers, as well as manner of communication between them. Moreover, it is the stage when the position of the assessment panel is settled in the organisational structure of the enterprise. Another significant issue is selecting the degree of complexity while applying the method, which actually comes down to answering the questions whether the method is to be applied to one or more workstations, and which elements of working conditions will be taken into account in the method.

Ad. 2. Qualitative representation of working conditions is a stage of the method whose aim is to relate the category of quality to the particular elements of working conditions. The product of this stage is a systematised set of features of working conditions (working conditions' quality).

Ad. 3. Establishing the priorities of the criteria for the assessment of working conditions' quality is the stage of the method whose aim is to obtain quantitative priority indicators for the particular criteria of assessment of working conditions' quality by applying the modified Thurstone's method or the Analytic Hierarchy Process technique (AHP) (Satty, 1988; Dong et al., 2010).

Ad. 4. The classification of the working condition's features is the stage whose aim is to classify the working conditions' features identified in the previous stage to one of four groups and, on this basis, to take adequate managerial actions aiming

at appropriate modelling of the features' state. In this stage, the classification of the working conditions' features will be carried out with the use of Grey Clustering Analysis (Sifeng, Lin, 2006). In order to deliver input data to Grey Clustering Analysis, the aggregation of experts' judgement and converting the descriptive assessment into a quantified one is conducted with the use of an appropriate assessment scale and mathematical computational formulas for data entropy.

Ad. 5. Determining and implementing managerial actions is the stage whose aim is to point out the directions of augmenting the working conditions' quality by formulating actions to correct the existing state of working conditions' quality and by formulating prophylactic actions to eliminate the potential inconsistencies related to the modelling of working conditions' quality.

3. SCHEME OF CONDUCT FOR EACH STAGE OF APPLYING THE METHOD

3.1. Establishing the panel on working conditions and determining the scope of applying the method

The starting point of applying the method is establishing the panel on working conditions in the enterprise. It ought to comprise people who have organisational authority in the capacity of the production process, people who have knowledge of the technologies employed in the enterprise and the representatives of organisational units for quality evaluation, as well as the specialist managing issues of occupational health and safety in accordance with law. If needed, experts from the outside can be appointed to join the panel (for instance, they can be specialists in acoustics or chemical agents, a qualified ergonomics specialist, an electrician or mechanic etc.). Appointing external experts entails additional expenses; nevertheless, it is necessary in many cases. Such a necessity might result from the lack of adequately qualified staff in the enterprise. A significant principle ruling the establishment of the panel on working conditions ought to be appointing the people directly managing the production process. Such members identify with the results of the panel's work more than in the case when the team is dominated by external experts or employees fulfilling advisory or administrative functions in the enterprise. The appointed panel ought to be established by the top management in accordance with the organisational principles of the enterprise. The leadership of the appointed panel ought to be entrusted to the occupational health and safety specialist. The head of the panel ought to elaborate a schedule of the panel's meetings and keep a record of these meetings in accordance with the assumptions for the method. Another significant issue is the panel's position in the organisational structure of the enterprise. Because of the interdisciplinary and supra-functional character of the group it ought to be directly subordinated to the Chief Executive Officer of the

enterprise, who should approve the managerial actions elaborated by the panel and hand them over for implementation, in accordance with the organisational order adopted in the enterprise.

The first and foremost task of the established panel on working conditions is determining the scope of application of the method. The scope of the method ought to be determined within the context of the economic, legal and technical conditions of the enterprise's functioning. The degree of complexity, determined from the subjective and the objective perspectives, should result from these conditions. In the subjective context, the degree of complexity is determined by the number of workstands subject to the method, whereas in the objective context it is the number of the elements of the working environment which determine the degree of complexity. For instance, the application of the method can be limited to one workstation, still covering all elements of working conditions. Another solution might be applying the method to many workstations, while focusing on the issues of the material working environment. A further significant issue as regards complexity is also the fact that in the method, the basic element is always a single workstation. Therefore, there is no possibility to carry out any methodical actions in which many workstations are treated as one object of analysis. For instance, when there are several workstands carrying out actions in the production process, each workstand has to be analysed separately. It is when one possesses the results of the analysis for each individual workstand, that one can carry out a synthesis within the scope of formulating managerial actions.

3.2. Qualitative representation of working conditions

On the most general level, working conditions' quality is made up of the quality of their particular elements. Among the latter, in accordance with the praxeological approach to work as an activity, we can distinguish the following:

- subject of work,
- aims of work,
- tools of work,
- material of work,
- method of working,
- work environment.

Such division enables to determine the working condition's quality in a systematised way, and imposes the structure of the documenting process.

Because of the variety of working conditions to be found in the practice of enterprises' functioning, it is difficult to create a universal list of working conditions' features. Therefore, in each case, the panel on working conditions, whose task is to consider the conditions and limitations in the particular enterprise, plays such a significant role in determining working conditions' quality.

3.3. Establishing the priority of criteria for assessing the working conditions' quality

General and universal criteria for the assessment of working conditions' quality adopted in the method are the criteria of ergonomics and performance. Ergonomic criteria include occupational safety, as well as the degree of harmfulness and onerousness. On the other hand, the group of performance criteria involve work effectiveness and work efficiency. The above-mentioned criteria, depending on the conditions in the particular enterprise, may have different priority in the assessment of working conditions' quality. Therefore, the issue of determining the priority precisely becomes exceptionally significant. In the method, two modes of establishing priority of the criteria are allowed. The first of them is based on the approach using the elements of preferential analysis for Thurstone's third quarter, while the other draws on elements of the AHP method. The selection of the variant applied to establish the priority of criteria has to be preceded by a multi-faceted analysis, taking into consideration the possibilities and limitations of the given organisation (Sagan, 2013; Becker, 2013; Dong et al., 2010) .

3.4. Classification of working conditions' features

The classification of working conditions' features is the element of the method which allows to classify given features of working conditions (specified in accordance with the principles presented in section 3.2) to one of four groups of features, and on the basis of it, enables to take appropriate managerial actions in further stages of the method. One of the schemes of grey systems theory, called Grey Clustering Analysis, applies in this element of the method, allowing to carry out the classification process in a quantified manner (Liu, Forest, 2010). The scheme of conduct in following successive steps allowing to classify working conditions' features has been presented below.

Step 1

In the first step of classification of working conditions' features, we need to adopt a set of classification criteria which we can label as $j = 1, 2, \dots, m$, and in accordance with the assumptions for the method, there will be only five criteria, namely:

- $j = 1$ will denote work effectiveness,
- $j = 2$ will denote work efficiency,
- $j = 3$ will denote occupational safety,
- $j = 4$ will denote harmfulness of work,
- $j = 5$ will denote onerousness of work.

Moreover, in this step of the classification process, each of these five criteria ought to have their priority η_j established according to the principles presented in section 3.4.

Step 2

In this step, one needs to determine the x_{ij} value, which is the assessment of the condition of the i -th feature in relation to the j -th criterion, where the experts assess how the current state of the features influences the j -th criterion with the use of a scale from 0 to 10, where zero stands for very negative influence on favourable modelling the state of the j -th criterion, and 10 denotes very positive influence on modelling the state of the j -th criterion. Having obtained the experts' judgments, the next stage in this step of conduct is determining the shared assessment of x_j value, with the use of formula (1) (Szafranski, 2006).

$$x_{ij} = \frac{\sum_{i=1}^n x_{ijn}}{n} - c_h h \quad (1)$$

where:

x_{ij} – collective assessment of the state of the i -th feature in relation to the j -th criterion,

x_{ijn} – collective assessment of the state of the i -th feature in relation to the j -th criterion by the n -th expert,

c_h – proportionality coefficient, whose standard value is adopted as 0.1,

h – the range between the highest and the lowest rank of the i -th feature in relation to the j -th criterion from the set of ranks appointed by m experts.

Step 3

In this step, one needs to establish groups of features $k = 1, 2, \dots, s$, where in the presented method, the following groups of features have been established *a priori*:

- the group, in which the state of features is not accepted ($k = 1$),
- the group, in which the state of features can be accepted under particular conditions ($k = 2$),
- the group, in which the state of features is accepted with certain reservations ($k = 3$),
- the group, in which the state of features is fully accepted ($k = 4$).

Step 4

In this step, we determine the whitening weight function $f_j^k(x_j)$ for each k group in relation to the j criterion. For the adopted four groups of features they will be qualified to, the whitening weight functions have been determined. In the analytical form, whitening weight functions have been defined with formulas (2a)–(2d).

$$f_{j=1,2,3,4}^1(x_j) = \begin{cases} \frac{2}{5}x & \text{for } 0 \leq x \leq \frac{5}{2} \\ -\frac{2}{15}x + \frac{4}{3} & \text{for } x > \frac{5}{2} \end{cases} \quad (2a)$$

$$f_{j=1,2,3,4}^2(x_j) = \begin{cases} \frac{1}{5}x & \text{for } 0 \leq x \leq 5 \\ \frac{1}{5}x + 2 & \text{for } x > 5 \end{cases} \quad (2b)$$

$$f_{j=1,2,3,4}^3(x_j) = \begin{cases} \frac{2}{15}x & \text{for } 0 \leq x \leq \frac{15}{2} \\ -\frac{2}{5}x + 4 & \text{for } x > \frac{15}{2} \end{cases} \quad (2c)$$

$$f_{j=1,2,3,4}^4(x_j) = \frac{1}{10}x \quad (2d)$$

The form of whitening weight function in the source literature is not precisely defined and ought to be selected with respect to the specific nature of the conducted classification. However, it is a good practice to select a triangular function, since it is simple to determine in an analytical form. The functions presented as formulas (2a)–(2d) have been created in the following manner: the range between the maximum values of whitening weight function were identical for each k criterion, which, with four groups where the working conditions' features will be classified and the range of variability for the assessment of these features by the experts from 0 to 10, gives us maxima of 2.5 and its multiples up to and including 10.

Step 5

In this step, the constant-weight clustering coefficient is determined according to formula (3).

$$\sigma^k = \sum_{j=1}^m f_j^k(x_j) \quad (3)$$

Subsequently, decision-making coefficient ought to be established according to formula (4).

$$\sigma^{k*} = \max\{\sigma^k\} \text{ for } 1 \leq k \leq s \quad (4)$$

The decision-making coefficient informs about the features' affiliation to a particular group. It is achieved by a procedure in which k superscript of the maximum, constant-weight clustering coefficient signalises the affiliation to a given group.

3.5. Determining managerial actions

The classification of working conditions' features enables to undertake adequate managerial actions depending on the group to which a given feature was classified on the basis of its current state. Hence, for:

- *the group, where the state of the features is not accepted*, actions have a corrective character and have to be taken immediately because of the fact that the states of these features may have negative influence not only on the performance, but also on the ergonomics of work, and especially on the occupational safety and the degree of harmfulness for the employees,

- *the group, where the state of features can be accepted under particular conditions*, the actions have a corrective character and ought to be taken immediately. However, in justified cases, when the state of a feature is modified in a proper way to eliminate problems related to harmfulness and employees' safety, it is acceptable to delay actions and to take them up at a later time, considering the fact that the optimum use of the workstand will not be achieved,

- *the group, in which the state of features is accepted with certain reservations*, the actions ought to have a corrective character, while the urgency of these actions should be dependent on the functioning conditions of the enterprise. These actions do not need to have high priority,

- *the group, in which the state of features is fully accepted*, the actions ought to have a preventive character, with particular attention to systematic control of the state of features, so that they do not change their state to unfavourable as a result of the environment's dynamics.

Managerial actions ought to be elaborated by the panel on working conditions, in accordance with the above-mentioned guidelines. It is significant that elaborating managerial actions finally results in a plan of action directly approved by appropriate persons within the organisational structure of the enterprise. Another vital issue is the appropriate structure and content of the elaborated plan, which has to comply with the requirements of purposefulness, feasibility, internal consistency, operativity, plasticity, appropriate minuteness, completeness and timing. The above-mentioned characteristics of a good plan ought to be communicated to the panel on working conditions' quality with the aim of their uniform interpretation. The structure and the content of the plan have to be accompanied by appropriate form. Because of the issues of transparency and readability, it is advisable to adopt the form of a table (Kotarbiński, 1970).

4. CONCLUSION AND FUTHER WORKS

The advancements in information technology and the widespread access to it in business, result in that it is purposeful to enquire about the possibility of its application when preparing any methodical solutions. The response to this enquiry gains particular significance when we encounter the problem of a large number of calculations. Undoubtedly, computational procedures applied in the elaborated method require tedious and frequently time-consuming mathematical calculations. Therefore, it is worth considering how to employ the available computer tools to facilitate and accelerate this process.

Furthermore, it ought to be claimed that the concept of quality evaluation of working conditions presented in the article should be empirically verified in a production enterprise's reality. Such a verification should be carried out in terms of reproducibility, replicability and formal correctness of the applied calculation procedures. These studies need to be conducted with the use of an inductive methodology of verification.

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METODA EKSPERCKO-KLASTROWA OCENY JAKOŚCI WARUNKÓW PRACY

Streszczenie

Celem artykułu jest prezentacja autorskiej metody oceny jakości warunków pracy. Koncepcja metody oparta jest na wykorzystaniu oszacowania eksperckiego oraz zastosowaniu algorytmu klasyfikacyjnego wywodzącego się z teorii systemów szarych. Opracowana metoda na płaszczyźnie teoretycznym odwołuje się do prakseologicznego ujęcia pracy jako specyficznego działania oraz do podejścia jakościowego w ujęciu kwalitologicznym.

Słowa kluczowe: jakość, warunki pracy, teoria systemów szarych

