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Małgorzata LOTKO
Aleksander LOTKO

CLUSTER ANALYSIS OF KNOWLEDGE WORKERS ASSESSMENT OF OCCUPATIONAL THREATS AND ATTITUDES TO CHARACTER OF WORK

ZASTOSOWANIE ANALIZY SKUPIEŃ DO OCENY ZAGROŻEŃ ZAWODOWYCH PRACOWNIKÓW WIEDZY I ICH POSTAW WOBEC CHARAKTERU PRACY*

The goal of the paper was to discover, if knowledge workers' occupational threats can be linked to some logical constructs and if knowledge workers can be grouped into some logical items concerning their assessment of these threats and attitudes to character of work. On a basis of literature studies peculiarity of knowledge-based work and specific occupational threats were identified. They were examined as observable variables with the use of a questionnaire method on a sample of 500 knowledge workers. Then, variables were classified using multidimensional exploratory technique - cluster analysis. As a research implication, the structure of perception of knowledge workers' occupational threats and their attitudes to character of work were revealed. As a practical implication, a proposed classification of variables allows to measure perception of occupational threats and use the results e. g. when designing trainings on occupational health and safety and to better fit them to this specific group of employees. Thus, job safety can be effectively improved by raising awareness of certain threats. The paper's contribution is a novel way of measuring and classifying knowledge workers' occupational threats and attitudes to character of work.

***Keywords**: knowledge workers, occupational threats, character of work, assessment, cluster analysis.*

Celem artykułu było zbadanie, czy zagrożenia zawodowe pracowników wiedzy mogą być pogrupowane w logiczne konstrukty i czy pracownicy wiedzy mogą być logicznie pogrupowani biorąc pod uwagę ich ocenę zagrożeń i postawy wobec pracy. Na podstawie studiów literaturowych zdefiniowano szczególny charakter pracy opartej na wiedzy i zagrożeń związanych z jej wykonywaniem. Zbadano je empirycznie jako zmienne obserwowalne z wykorzystaniem metody ankietowej na próbie 500 pracowników wiedzy. Następnie przeprowadzono klasyfikację zmiennych z wykorzystaniem wielowymiarowej techniki eksploracyjnej – analizy skupień. Jako wniosek badawczy odkryto strukturę postrzeganych przez pracowników wiedzy zagrożeń zawodowych. Jako wniosek praktyczny, proponowana klasyfikacja zmiennych pozwala mierzyć postrzeganie zagrożeń zawodowych przez pracowników wiedzy i wykorzystać wyniki np. podczas projektowania szkoleń z zakresu bezpieczeństwa i higieny pracy, aby lepiej dopasować je do tej szczególnej grupy pracowników. Dlatego bezpieczeństwo pracy może być wyraźnie poprawione poprzez podniesienie świadomości określonych zagrożeń. Wkładem artykułu jest nowatorski sposób pomiaru i klasyfikacji zagrożeń zawodowych przez pracowników wiedzy i ich postaw wobec pracy.

***Słowa kluczowe**: pracownicy wiedzy, zagrożenia zawodowe, charakter pracy, ocena, analiza skupień.*

1. Introduction

Knowledge is the source of competences, improvement of efficiency and effectiveness of management and productivity [10, 21, 54]. Knowledge workers deal with creating, processing, applying and disseminating knowledge and information. They constitute a group educated in a formal way, however they understand the wide context of work, creative thinking, creativity, openness to changes and challenges as well as exercise treatment of work. They are responsible for creation and implementation of new ideas thanks to which organizations can better adapt to the rapid changes taking place in the surrounding environment. In contemporary economy, this particular group is becoming even more numerous. Still, specification of work based on knowledge triggers new occupational threats. Advantage of psycho-sociological threats over physical threats is a characteristic phenomenon [35].

Proper relations in the human-technique-environment system constitute a necessary condition to provide safety and well-being of a worker in the working process. Performance of every work is strictly connected with the occurrence of various type of threats. Occupational threats constitute potential events which by virtue of their appearance, i.e. occurrence in practice, exert a negative impact on the working environment or psychophysical condition of the workers. Such events may cause accidents at work or occupational diseases. Every factor and/or situation which may cause such accident or disease constitutes a threat in the working environment.

The goal of the paper was to discover, if knowledge workers can be grouped into some logical items concerning their assessment of occupational threats and character of work.

From such defined a goal, the following research hypotheses were drawn:

- H1: occupational threats posed to knowledge workers can be grouped into few logical items.
- H2: knowledge workers can be grouped into clusters according to their perception of occupational threats.
- H3: there are between cluster differences according to demographical variables.
- H4: there are between cluster differences according to the department and role in organization.
- H5: there are between cluster differences according to the assessment of the character of knowledge-based work.

(*) Tekst artykułu w polskiej wersji językowej dostępny w elektronicznym wydaniu kwartalnika na stronie ***www.ein.org.pl***

The aim was reached and the hypotheses were verified on the basis of the results of empirical research with the use of multidimensional exploratory techniques.

2. Professions and knowledge workers – the state of the art

Issues concerning knowledge workers are mainly discussed by the following foreign authors: T. Davenport [8], P. Drucker [11], W. Cortada [4], D. Jemielniak [27], J. Patalas-Maliszewska [48], J. Evetts [13], M. Roell [51], M. Granitzer and S. Linsteadt [18], D. Kleinmann and S. Vallas [30], and in Poland: E. Skrzypek [54, 53], M. Morawski [44, 42], G. Filipowicz [15], T. Kawka [28], D. Makowski [38], D. Jemielniak [26], M. Staniewski [57] and K. Łysik [37]. Authors conducting research in this topic define the term of knowledge workers (W. Cortada, D. Jemielniak, D. Makowski, T. Kawka), they also present the results of research concerning their creativity (E. Skrzypek), productivity (M. Granitzer and S. Linsteadt; E. Matson and L. Prusak [39]) and effectiveness (G. Filipowicz), as well as group work (K. Lewis [33]), motivation [27], communicating (D. Straub and E. Karahanna [60]) acquisition (B. Mikuła [41]) and sharing knowledge (M. Roell, K. Czop and D. Mietlicka [6]), specification of work based on knowledge (D. Jemielniak [26]) as well as methods of managing knowledge workers (T. Davenport, J. Patalas-Maliszewska, M. Morawski, M. Staniewski), management models (J. Patalas-Maliszewska) and challenges (K. Łysik) in this area. However there are no analyses available concerning self-awareness and self-assessment of work's character conducted by particular knowledge workers. Consequently we can observe a research gap which we tried to eliminate at least partly by means of this study.

Complexity of the management of knowledge in organizations and the lack of applicable definition of the knowledge worker result in the establishment of a number of various classification schedules connected with the processing of knowledge. Thus Ch. Handy divides workers into three categories [21]:

- routine workers – employed in order to operate shop cash desks or to enter data on floppy disks,
- suppliers of external services,
- analytics who work with numbers, ideas and words – journalists, financial analytics, consultants, architects, managers, etc.

M. Morawski claims that a knowledge worker is perceived in the context of formal education often exceeding the average level, he combines knowledge with different disciplines and at the same time he possesses deepened specialist knowledge and particular solid and practical skills based on the specialist knowledge, which are very often beyond the access of others [43]. Whereas T. Davenport acknowledges that knowledge workers are distinct from office workers as they not only process data by means of process of thinking but they also analyse them, understand them and create new knowledge in terms of its quality [8]. At the same time "they do not like to receive instructions, the mode of their work is difficult to be organized and foreseen, the best results are achieved when working with others in the contact nets".

A good example of knowledge workers constitute representatives of independent professions such as: doctors, attorneys, chartered accountants or architects [37]. E. Skrzypek maintains that knowledge workers are professionals processing symbols, paid for the effectiveness [53]. They have professional skills, interpersonal competences and unique competences the use of which creates an added value included in modern products and technologies"; they create, keep, apply and disseminate knowledge. According to C. Sikorski [52] the most important workers existing in modern economy, are psychologically ready for frequent changes at work, are not afraid of these changes, are flexible and they eagerly take risk, are not focused on a long-lasting career in one organization and are oriented towards the result – they have a strong need for achievements supported by a pursuit of continuous learning and a will to exert impact on the environment being subject to a minimalized control.

An interesting and wide review of definitions and features of knowledge workers are among other discussed by: T. Davenport [8], P. Drucker [10], A. Kidd [29], D. Kleinmann and S. Vallas [30], M. Strojny [61], T. Kowalski [31], A Fazlagić [14] or J. Szaban [62].

3. Threats to knowledge workers – the state of the art

Contemporary environmental and professional threats require a wider and deeper study [19, 16, 1]. The World Health Organization (WHO) promotes the strategy of health and safety at work [64], and the International Labour Organization (ILO) promotes the safety of work in the „green economy" of sustained development, which brings new and unknown threats to the workers [25]. Attention is also paid to the specific nature of occupational threats in the information society [34]. A threat is a potential source of a damage i.e. of an injury or other kind of deterioration of health [49]. A dangerous situation is a situation in which a given person is exposed to at least one danger. Such exposure may cause damage immediately or after some time.

The interest of the empirical part of this study is the assessment of occupational threats of the knowledge workers. The author discussed this issue in her previous works [36, 35, 34]. The awareness within the scope of occupational threats is particularly significant as the most frequent cause of accidents at work constitute the consequences of improper conduct of a worker [3]. On the other hand studies in the way the workers perceive their organization, concentrate on three different aspects of its functioning and culture: as the environment to solve problems and as the environment of self-development [5]. Within the first of the aspects mentioned above, one of the stress-causing factors constitutes the role served by a worker in a given organization. This threat mainly relates to the problems connected with the conflict of the roles in organization and responsibility for other people as well as to the possibility to receive support from the management and co-workers [32]. Uncertainty connected with the development of the professional career of a knowledge worker and uncertainty regarding the employment are both perceived as a serious threat. Threats resulting from the work itself include working environment, project of the task, pace of work and work schedule. Monotonous repeatability of tasks, insufficient use of worker's skills, incompatibility of duties and capabilities of a worker and a high level of uncertainty, these are the kind of stress-causing threats connected with a particular type of work performed by a knowledge worker. Significant threats resulting from the work itself include work schedule and pace of work leading to overwork [24, 9]. Threats listed above have a psychological background.

Another group of threats are threats resulting from improper organization of work. Factors limiting occupational threats of organizational character include breaks during work, possibility to perform various tasks, freedom of decisions concerning the manner of performance of the entrusted work, attainable deadlines for the performance of duties [3].

When considering technical threats we should take into account the peculiarity of a given workplace. Workers perform the majority of their duties using office electronic equipment. Work stations should have an access to the day light and electric light. Work with a computer monitor, minimisation of personal computers including the monitors results in sight disorders. Moderate temperature and quietness are important elements for conceptual work. On the other hand non-ergonomic position at work results in disorders of musculoskeletal system and spine injuries. Seemingly not dangerous, but the effect of such disorders and injuries is cumulating for years what causes chronic illnesses which very often require a long-term treatment [36].

The last group of threats to the working environment of knowledge workers includes safety threats concerning the „material" of

which the knowledge is made of, i.e. data and information processed in an organization, especially in the environment of computer networks. Basic attributes defining safety of information are confidentiality, integrity and accessibility [50]. Threats to these attributes are of psycho-sociological and stress-causing character.

4. Research methodology

Sampling was purposive – among working students of the University of Technology and Humanities in Radom 500 persons were selected, who specified the nature of their work as a "knowledge worker". The adopted methodology provided the veracity of one of the qualification criteria of the knowledge workers concerning the possession of formally documented specialist knowledge – they had at least a bachelor or engineer title.

A questionnaire method was applied to collect statistical material whereas the author designed a special tool, i.e. a questionnaire form. Examined knowledge workers filled in the questionnaire composed of 28 questions. The first five questions were in the form of a certificate, the next 7 questions evaluated the self-awareness of the knowledge workers and the last 16 concerned the assessment of occupational threats (placed in table no. 3). Observable variables concerning the self-assessment of worker's knowledge and the assessment of occupational threats was described on the five-point Likert scales which measure the compatibility degree of a given respondent with a particular statement. For the purpose of the study of statistical material, a questionnaire method was used, whereas the author designed a special tool in the form of a questionnaire. Because of the assumed scales, where each item is described by a positive statement, low value of a variable means perceiving threat as a weak one, as high value of a variable means perceiving threat as a strong one. Such an approach allowed to treat occupational threats as "hidden" ones, not expressed in an explicit manner, hence not dictated to the surveyed employees.

Cluster analysis was used during this study. The term cluster analysis was introduced by R. Tryon [63] and then developed by R. Cattell [2]. The use of cluster methods has increased dramatically in the last 30 years [17]. Cluster analysis encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories. A general question facing researchers in many areas of inquiry is how to organize observed data into meaningful structures, that is, to develop taxonomies. In other words cluster analysis is an exploratory data analysis tool which aims at sorting different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise [58]. Cluster analysis is a term used to describe a family of statistical procedures specifically designed to discover classifications within complex data sets. The objective of cluster analysis is to group objects into clusters such that objects within one cluster share more in common with one another than they do with the objects of other clusters. Thus, the purpose of the analysis is to arrange objects into relatively homogeneous groups based on multivariate observations. cluster methods are used to group people (or other objects) together based on their scores across a set of variables [17].

Cluster analysis can be used to discover structures in data without providing an explanation and interpretation. In other words, cluster analysis simply discovers structures in data without explaining why they exist [58]. This method is unsupervised, which means that all the relationships are found only on a basis of input variables. It should be added, that cluster analysis is not as much a typical statistical test as it is a collection of different algorithms that put objects into clusters according to well defined similarity rules. The point here is that, unlike many other statistical procedures, cluster analysis methods are mostly used when we do not have any a priori hypotheses, but are still in the exploratory phase of our research.

Cluster methods lend themselves to use by investigators considering a wide range of empirical questions. Investigators in the life sciences, for example, are often interested in creating classifications for life forms, chemicals, or cells. They may be interested in developing complete taxonomies or in delimiting classifications based on their particular research interests. Medical scientists rely on clinical diagnoses and may use cluster methods to identify groups of people who share common symptoms or disease processes. The use of cluster methods in the behavioral sciences is as varied as the fields that constitute this branch of inquiry. A psychologist might be interested in exploring the possible relations among types of counseling interventions. In contrast, the economist may be charged with identifying economic similarities among developing countries. Clustering methods are useful whenever the researcher is interested in grouping together objects based on multivariate similarity [17].

D. Speece [56] encourages researchers to consider the purpose for their classification during this stage of the study. Cluster analysis may be used to develop a typology or classification system, as a test of existing classification systems, or simply to explore possible undiscovered patterns and similarities among objects. This author notes that classification systems may be used either to promote communication with practitioners or to enhance prediction.

Clustering techniques have been applied to a wide variety of research problems. Whenever it is needed to classify a large amount of information into manageable meaningful piles, cluster analysis is of great utility. The methods used in cluster analysis encompass [58]:

- joining (tree clustering),
- k-means clustering,
- two-way joining,
- expectation maximization clustering.

Two types of clustering algorithms can be distinguished: hierarchical and non-hierarchical. Hierarchical methods lead to creating a hierarchical tree-like structure of the elements of the analyzed set, which in its horizontal version is called a tree plot, and in its vertical version - an icicle plot. So, the effects of the algorithm can be presented as a tree, which shows the next steps of the performed analyses [40]. This way a final segmentation can be obtained, which means an orderly combination of a breakdown into segments. Different methods can be used here. Owing to the efficiency of reproducing the real data structure, the Ward method is recommendable. It uses the rule of minimizing variation [40]. These methods do not require an earlier assumption on the number of clusters – a plot can be "cut off" on a proper height in the end of an analysis and then interpreted. As a criterion for specifying an optimal number of segments, the first distinct growth of the distance, implying from the analyses of the distance graph for the next stages of bonding can be acknowledged. However, for the large data sets they require high computing power. The most popular method here is joining (tree clustering). In turn, non-hierarchical methods are quick to calculate, but they require to declare the assumed number of clusters in advance, which strongly influences the quality of obtained segmentation. Here, a method of k-means is very popular.

The joining or tree clustering method uses the dissimilarities (similarities) or distances between objects when forming the clusters. Similarities are a set of rules that serve as criteria for grouping or separating items. The most straightforward way of computing distances between objects in a multi-dimensional space is to compute Euclidean distances. This is probably the most commonly chosen type of distance. It simply is the geometric distance in the multidimensional space [58].

Summing up, a concise and relevant review of the development, applications, methods and problems of cluster analysis is provided by P. Gore [17]. Interesting and classical examples of cluster analysis applications are discussed by T. Hastie, R. Tibshirani and J. Friedman [23] as well as P. Guidici and S. Figini [20]. Also, an excellent sum-

mary of the many published studies reporting the results of cluster analyses is provided by J. Hartigan [22].

It the paper, the clustering methods were used twice:

1. Firstly, to check if the latent variables can be grouped into some clusters describing knowledge workers occupational threats posed to knowledge workers. The analysis was performed by clustering variables (by columns).
2. Secondly, to check if knowledge workers can be grouped into clusters according to their assessment of occupational threats. The analysis was performed by clustering cases (by rows), firstly using Ward method to identify the number of clusters, then using a k-means method to group cases and interpret them on a basis of a mean value of each variable in each cluster.

5. Discussion on the results of the study

Firstly, grouping variables by columns was performed. The aim was to examine the research hypothesis H1 stating that occupational threats posed to knowledge workers can be grouped into few logical items. A vertical tree graph (icicle plot) drawn in Figure 1 shows clusters for occupational threats obtained in another steps, while graph in Figure 2 shows the growth of linkage distance in another steps (iterations).

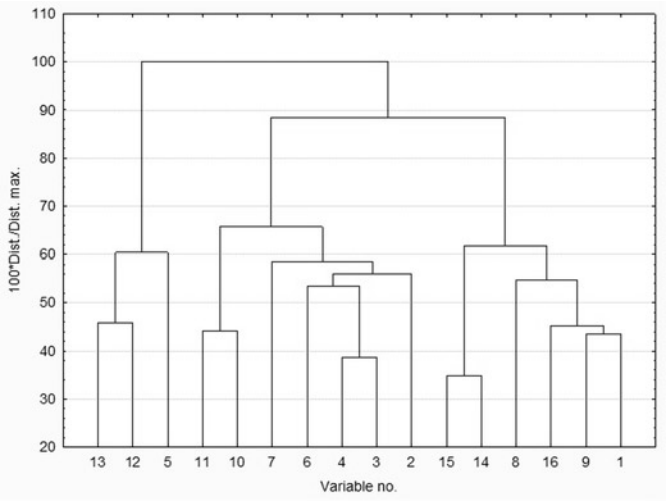

Fig. 1. Icicle plot for occupational threats cluster analysis. Source: authors' own study

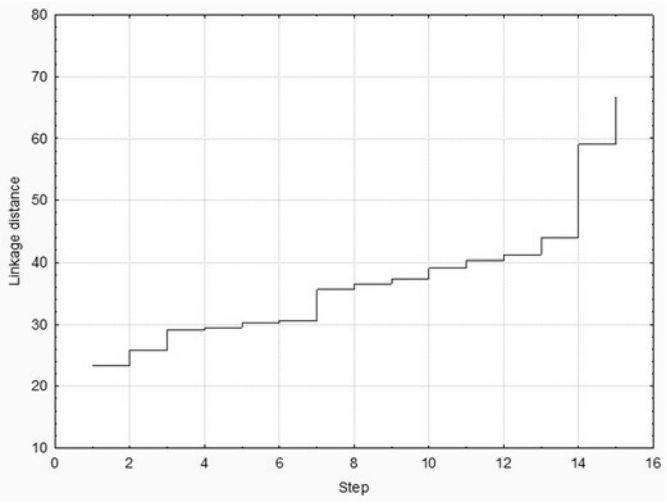

Fig. 2. Linkage distance in another steps for occupational threats cluster analysis. Source: authors' own study

From Figure 1 it can be seen that cutting a plot off at a standardized linkage distance e. g. 62, 4 clusters are obtained. Then, Figure 2 shows that the distinct increase in linkage distance appear in 7th and 14th of 15 steps of analysis. Interpretation of the obtained clusters is as follows (the order of linking variables was preserved, hence they are not sorted):

1. Cluster 1 - "physiology" (P), links variables 13, 12, 5, linking mainly physiological threats (threats to sight and musculoskeletal system) and the pressure of time.
2. Cluster 2 – "physical conditions" (F), links variables 11, 10, linking physical conditions at a workplace (temperature, noise, ability to concentrate).
3. Cluster 3 – "psycho-sociology" (S), links variables 7, 6, 4, 3, 2, linking psycho-sociological threats – ability to decide about the way of performing work, ability to relax, proper use of worker's abilities, estimation of the future and salary satisfaction.
4. Cluster 4 – "data and autonomy" (D), links 15, 14, 8, 16, 9, 1, linking threats posed to data security (confidentiality, integrity, availability), illumination of a workplace, diversity of tasks at work and support in performing them.

Analysis shows, that it is hard to logically interpret joining variables to clusters in 2 cases: variable 5 (pressure of time) to the cluster 1 and variable 9 (illumination of a workplace) to the cluster 4. Mapping variables describing occupational threats to clusters is given in Table 1.

Table 1. Mapping observable variables to clusters

Var.	Statement	Mapping to a cluster
1	I can count for the support in solving problems encountered at work.	D1
2	I am satisfied with the remuneration that I receive.	S1
3	I perceive the future of my career optimistically.	S2
4	My skills are properly used in organization.	S3
5	I work under time pressure.	P1
6	Breaks at work allow me to relax.	S4
7	I make the decisions concerning the manner in which I perform the work by myself.	S5
8	Performed tasks are diversified.	D2
9	My work station has appropriate lighting.	D3
10	At my work station, the temperature is at a comfortable level.	F1
11	Surrounding of my work station allows for concentration.	F2
12	During the work my eyesight can rest.	P2
13	During the work I have comfortable and ergonomic position.	P3
14	Data and information used at work are at the disposal of authorised persons only.	D4
15	Data and information used at work are protected from unauthorised modification.	D5
16	Data and information used at work are available when necessary.	D6

Source: authors' own study

Although this is a bit different classification than the one obtained with the use of factor analysis, where 5 factors (dimensions) were discovered [34], the hypothesis H1 was verified.

Because of the assumed scales, where each item is described by a positive statement, low value of a variable means perceiving threat as a weak one, as high value of a variable means perceiving threat as a strong one. Such an approach allowed to treat occupational threats as "hidden" ones, not expressed in an explicit manner, hence not dictated to the surveyed employees. Having the clusters linking occupational threats defined, it is now possible to measure the value of each of the groups of threats. The profile of occupational threats assessment is shown in Figure 3.

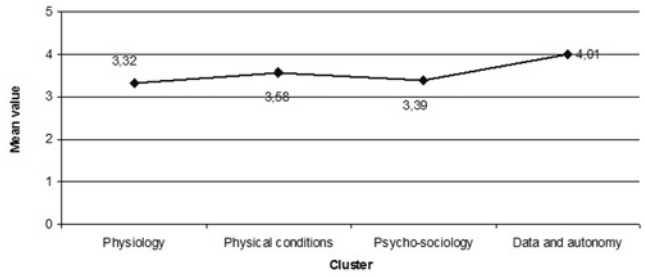

Fig. 3. Assessment of occupational threats clusters (mean values), Source: authors' own study

From Figure 3 it can be read that knowledge workers' perception covers mostly threats coming from physiology and psycho-sociology (there are low values of positive statements). Threats concerning physical conditions and threats to data security and lack of autonomy are perceived as relatively weak.

Then, grouping variables by rows (cases) was performed. The aim was to examine the research hypothesis H2 stating that knowledge workers can be grouped into clusters according to their perception of occupational threats. A vertical tree graph (icicle plot) in Figure 4 shows clusters for cases obtained in another steps, and graph in Figure 5 shows the growth of linkage distance in another steps (iterations).

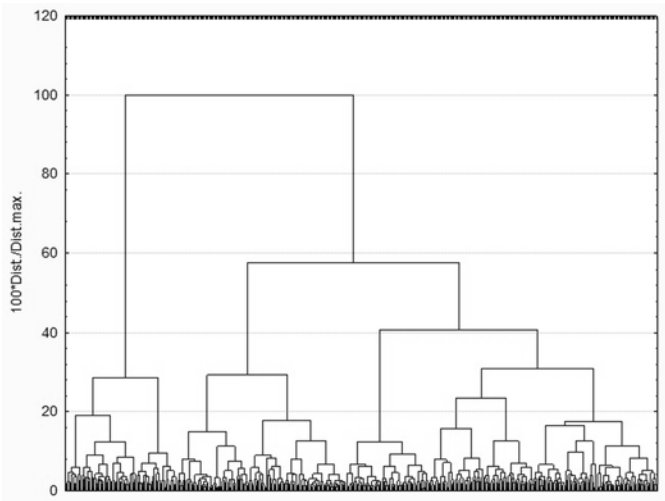

Fig. 4. Icicle plot for cases cluster analysis. Source: authors' own study

Table 2. Distances between clusters

Distance	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Cluster 1	0,000000				
Cluster 2	0,785190	0,000000			
Cluster 3	0,931778	0,957400	0,000000		
Cluster 4	1,623008	1,220837	1,071241	0,000000	
Cluster 5	1,005950	0,907696	1,246267	1,289286	0,000000

Source: authors' own study

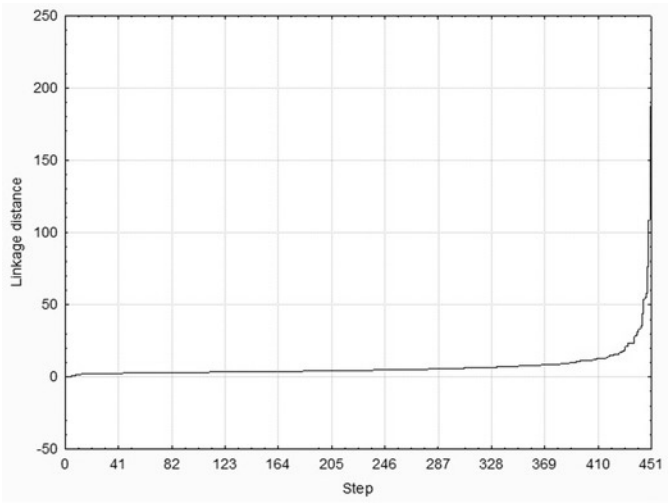

Fig. 5. Linkage distance in another steps cases cluster analysis. Source: authors' own study

From Figure 4 it can be concluded, that cutting the plot off at a standardized distance e. g. 30 allowed to identify 5 clusters. Then, Figure 5 shows that a substantial increase in a standardized linkage distance indeed took place in the last few iterations.

From Table 2 it can seen that there are considerable between cluster Euclidean distances – all of them are above 0,78. So it can be taken for granted that the clusters really reflect different groups of workers.

In Table 3 mean values of variables measuring assessment of occupational threats are given broken down into clusters and overall. These values are shown in Figure 6.

Table 3. Mean values of variables measuring assessment of occupational threats: in clusters and overall

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
1	4,43	4,36	4,35	3,20	4,25	4,19
2	3,88	2,09	3,35	1,95	2,52	2,93
3	4,20	3,31	3,68	2,26	3,09	3,46
4	4,29	3,57	4,00	2,71	3,83	3,80
5	3,01	3,10	2,91	3,68	3,99	3,32
6	4,24	3,68	3,83	2,59	2,41	3,46
7	4,16	2,16	3,28	2,14	3,66	3,29
8	4,24	3,48	3,95	3,00	4,24	3,89
9	4,62	4,61	3,95	2,68	4,09	4,13
10	4,30	4,23	3,66	2,09	3,07	3,61
11	4,29	3,71	3,92	2,26	2,84	3,54
12	3,12	3,12	2,77	2,82	4,52	3,32
13	3,02	2,81	3,03	3,15	4,56	3,33
14	4,48	4,30	2,35	2,65	4,64	3,91
15	4,39	4,35	2,12	2,39	4,69	3,83
16	4,45	4,47	3,25	3,17	4,51	4,10

Source: authors' own study

From Table 3 and Figure 6 it can be seen that the analysis of classifying cases into each of the 5 clusters, done with the use of a k-means method, allows to generalize the following conclusions regarding characteristic of each of the clusters according to the perception of occupational threats (because of the assumed scales, where each item is described by a positive statement, low value of a variable means perceiving threat as a weak one, as high value of a variable means perceiving threat as a strong one):

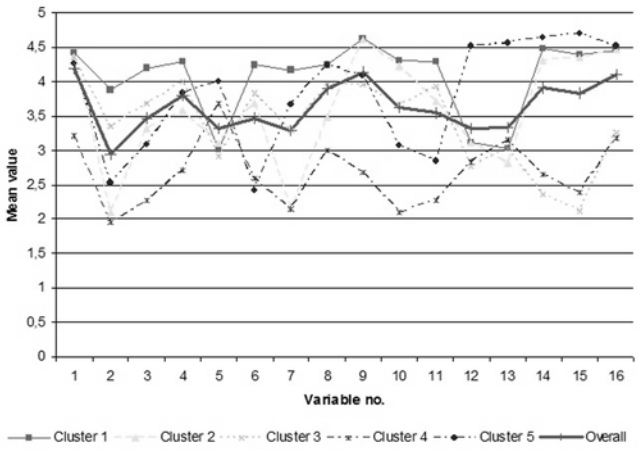

Fig. 6. Mean values of variables measuring assessment of occupational threats: in clusters and overall

1. Cluster 1 (linking 146 cases) „perceiving physiological threats" – most of variables are assessed rather highly, so this group of workers rather does not perceive occupational threats. Within this cluster variables 5, 12 and 13 have low values, what means that these workers are aware mainly of threats to an eyesight and implying from an uncomfortable position at work. These threats are of physiological character.
2. Cluster 2 (linking 77 cases) „perceiving psycho-sociological threats" – the assessment of threats is rather average for most of variables, highly assessed values are 1, 9 and 16, still the lowly assessed ones are 7, 8 and 11. Hence this group of workers perceives occupational threats mostly in psycho-sociological categories: lack of autonomy in choosing a way of realizing tasks, low diversity of tasks and difficulties with concentration at work.
3. Cluster 3 (linking 66 cases) „perceiving threats to information" – most of variables are have values near to average, low assessment accords to variables 14 and 15, so this group of workers perceives mostly threats posed to information, exactly to data confidentiality and integrity.
4. Cluster 4 (linking 67 cases) „lacking motivation, under esteemed and perceiving physical threats" – here many variables are of low values, especially 2, 3, 4, 8, 9, 10, 11, 12. These workers lack motivation and feels psycho-sociologically threaten. The main threats observed here are dissatisfaction from salary, pessimistic estimation of the future, improper use of a worker's skills and competencies, low diversity of tasks, but also the ones of a physical character: improper lighting, temperature and inability to concentrate (noise).
5. Cluster 5 (linking 95 cases) „perceiving bad organization of work process and physical conditions at work" – many variables are highly esteemed, nevertheless variables number 6, 10 and 11 have low values, so this group of workers perceives mainly threats implying from an organization of work process and physical conditions at a workplace (difficulties with relax, temperature, difficulties with concentration).

This way hypothesis H2 was verified.

Then, the research hypotheses H3 and H4 were examined, stating that there are between cluster differences according to demographical variables and that there are between cluster differences according to the department and role in organization accordingly. Table 4 includes the percentage of knowledge workers' sex broken down into clusters and overall.

Table 5 includes the percentage of knowledge workers' age grouped into ranges and broken down into clusters and overall.

Table 4. Percentage of sex: in clusters and overall

Sex	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
Man	48,98	64,00	36,92	45,45	71,13	53,88
Woman	51,02	36,00	63,08	54,55	28,87	46,12

Source: authors' own study

Table 5. Percentage of age: in clusters and overall

Age	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
<=27	42,18	56,00	56,92	40,91	38,14	45,45
28-37	29,93	24,00	10,77	21,21	21,65	23,06
38-47	12,24	10,67	9,23	21,21	17,53	14,19
48-57	8,16	4,00	18,46	15,15	17,53	11,97
>=58	7,48	5,33	4,62	1,52	5,15	5,32

Source: authors' own study

Table 6 includes the percentage of employees working in certain organizational divisions broken down into clusters and overall.

Table 6. Percentage of organizational divisions: in clusters and overall

Division	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
Office	44,90	46,67	21,54	21,21	48,45	38,14
Production	11,56	18,67	30,77	37,88	10,31	19,07
Marketing	6,12	6,67	4,62	7,58	4,12	5,76
Finance	10,88	2,67	3,08	7,58	8,25	7,32
Customer service	19,73	17,33	21,54	15,15	22,68	19,73
R&D	4,76	4,00	15,38	4,55	4,12	5,99
IT	2,04	4,00	3,08	6,06	2,06	3,99

Source: authors' own study

The classification of roles of knowledge workers was based on the one proposed by I. Nonaka and H. Takeuchi [47] and covers:

1. Knowledge practitioners: ordinary employees or lower management:
   a) Knowledge operators (operational management, employees interacting with customers, direct control employees).
   b) Knowledge specialists (R&D employees, planners, market researchers).
2. Knowledge constructors (tactical management, designers, programmers, engineers, marketers).
3. Knowledge leaders – higher management.

Table 7 includes the percentage of roles in organization broken down into clusters and overall.

Table 7. Percentage of roles in organization: in clusters and overall

Role	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
Knowledge operator	60,54	69,33	70,77	65,15	76,29	67,63
Knowledge specialist	19,05	16,00	15,38	15,15	10,31	15,52
Knowledge constructor	10,88	12,00	6,15	13,64	9,28	10,44
Knowledge leader	6,80	1,33	7,69	4,55	4,12	5,11

Source: authors' own study

In Tables 4–7 it is visible that each of the cluster is characterized by four features: two demographic (sex and age, shown in Tables 4 and Table 5 accordingly) and two organizational (division and role, shown in Table 6 and Table 7 accordingly). The results are given below:

1. Cluster 1 – the split between men and women is nearly equal. The highest percentage of employees in the age range 28-37 years belongs here. High percentage of office and financial division workers belongs here, still the percentage of production workers is small. These employees describe their role in organization mot often as knowledge specialists and knowledge leaders. So, according to discussed variables, cluster 1 can be named "young office leaders".
2. Cluster 2 – nearly 2/3 of these employees are men. Very high percentage of the young employees (27 or younger) belongs here. These are mostly office workers, the smallest percentage of financial division employees qualified to this cluster. Very few of this group are knowledge leaders, and proportion between knowledge operators, specialists and constructors is very similar to overall average. So, according to discussed variables, cluster 2 can be named "young not managing gentlemen".
3. Cluster 3 – this group is visibly "feminized". The structure of age is rather towards young personnel, still there is the highest percentage of employees aged 48-57 among all clusters. Only a few office workers are joined here, with a huge advantage of production and research & development workers. These employees define themselves as knowledge operators, but also knowledge leaders more than overall average. So, according to discussed variables, cluster 3 can be named "R&D ladies".
4. Cluster 4 – within this group a proportion of sex is close to equal. The structure of age is moved towards middle-aged employees. Very few office workers are joined to this cluster and the organizational divisions appearing meaningfully more often than overall average are production and IT. As to a role in organization, there is a highest percentage employees of all clusters defining it as "knowledge leader". So, according to discussed variables, cluster 4 can be named "middle-aged IT or production leaders".
5. Cluster 5 – this cluster is the most "masculine" of all, as nearly 3/4 of employees in this group are men. Also, there is a visible advantage of middle-aged and older employees, aged in the range 38–57. Nearly half of them are office workers and this is the highest percentage of all clusters. In this cluster there is the highest percentage of employees working in customer service as well. These workers clearly identify themselves mostly (over 3/4 of them) as knowledge operators (the highest percentage of all clusters). So, according to discussed variables, cluster 5 can be named "middle-aged office or customer service operators".

This way each of the clusters is characterized in terms of demography and organizational roles. So the research hypotheses H3 and H4 were verified.

At last, the research hypothesis H5 stating that there are between cluster differences according to the assessment of the character of knowledge-based work was examined. Variables describing a knowledge-based work character, also measured on a 5-point Likert scales, were as follows:

1. My work requires proper education.
2. In my work intellectual capital (experiences, thoughts, intellectual effectiveness) is of substantial meaning.
3. In my work I make use of unique specific and general competencies.
4. In my work I freely use telecommunication and information technologies.
5. In my work I am self-reliant, I solve tasks and problems by myself.
6. My work is results in creating innovations – new products or services.
7. My work requires permanent education, gathering new knowledge.

Table 8 includes mean values for variables measuring assessment of knowledge-based work character broken down into clusters and overall. These results are also shown in Figure 7.

Table 8. Mean values of variables measuring assessment of knowledge-based work character: in clusters and overall

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Overall
1	4,20	3,96	3,77	3,28	4,20	3,96
2	4,50	4,16	4,23	3,64	4,62	4,30
3	3,97	3,69	3,40	3,14	3,58	3,63
4	4,35	4,27	3,83	3,61	4,56	4,20
5	4,29	3,69	3,82	3,44	4,30	4,00
6	2,65	2,55	2,88	2,36	2,42	2,58
7	4,03	3,92	3,74	3,35	4,00	3,86

Source: authors' own study

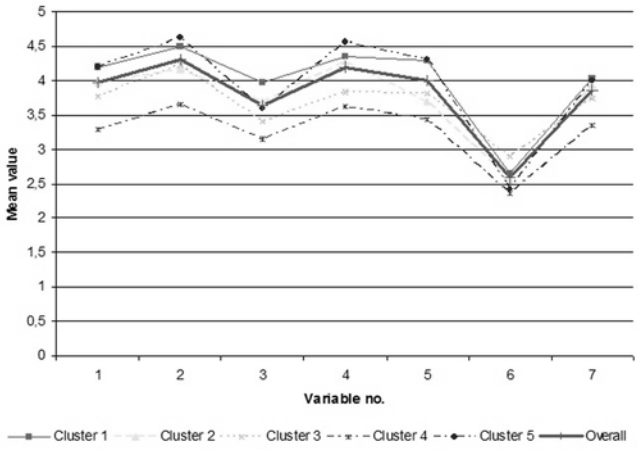

Fig. 7. Mean values of variables measuring assessment of knowledge-based work character: in clusters and overall

From the data in Table 8 and graph in Figure 7 it implies that in overall knowledge workers describe the character of their work as demanding high input of an intellectual capital (experiences, thoughts, intellectual effectiveness) (variable 2), requiring free usage of advanced telecommunication and information technologies (variable 4) and independency, autonomy, solving tasks and problems on one's own hand. These three variables have the highest mean value overall. What is interesting, the variable describing creating innovations – new products or services (variable 6) was assessed visibly on a lowest level. This means that knowledge workers perceive this feature rather as not a proper attribute for describing the character of their work.
Further, from breaking the analysis down into clusters, the following facts imply:

1. Knowledge workers joined to cluster 1 highly assess all of the variables, especially the ones concerning having proper education (variable 1), using unique general and specific competencies (variable 3), self-reliance (variable 5) and permanent education together with gathering knowledge (variable 7). So employees linked to this cluster can be called "education seeking and self-reliant".

2. Knowledge workers joined to cluster 2 assess the examined variables the average for most variables, still highly assessing the need of using unique general and specific competencies (variable 3) and a free use of information and telecommunication technologies. Hence they can be named "intensive IT-users".
3. Knowledge workers joined to cluster 3 estimate most of the determinants of the knowledge-based work character below the overall mean value, with one exception for the fact that their work results in creating innovations – new products or services (variable 6). So this cluster can be called "innovators".
4. Knowledge workers joined to cluster 4 assessed all of the variables well below the overall mean value. Hence this group can be named "noticing no special features of work" they do.
5. At last, knowledge workers joined to cluster 5 ascribed high values to most of the examined variables. Especially high values are given to variables describing the role of intellectual capital (experiences, thoughts, intellectual effectiveness) in the knowledge-based work (variable 2), a use telecommunication and information technologies (variable 4) and permanent education, gathering new knowledge (variable 7). So employees linked to this cluster can be called "intellectualists".
   So the research hypothesis H5 was verified.

6. Putting together the results of the so far study

Putting together demographical and organizational characteristics of the identified clusters of knowledge workers and the perception of character of work within each cluster the statements shown in Table 9 can be generated.

The results in table 9 seem sensible and easy to interpret. Each of the 5 statements in this table reflects the character of work defined by each cluster of knowledge workers.

Finally, putting together demographical and organizational characteristics of the identified clusters of knowledge workers and the perception of occupational threats within each cluster, the statements shown in Table 10 can be generated.

Again, each of the 5 statements shown in this table reflects the perception of occupational threats by each cluster of knowledge workers.

Table 9. Knowledge workers clusters in terms of demography and organization versus perception of character of work

Cluster No.	Cluster in terms of demography and organization	Verb	Cluster in terms of perceiving character of work
1	Young office leaders	are	education seeking and self-reliant
2	Young not managing gentlemen		intensive IT-users
3	R&D ladies		innovators
4	Middle-aged IT or production leaders		noticing no special features of work
5	Middle-aged office or customer service operators		intellectualists

Source: authors' own study

Table 10. Knowledge workers clusters in terms of demography and organization versus perception of occupational threats

Cluster No.	Cluster in terms of demography and organization	Cluster in terms of perceiving occupational threats
1	Young office leaders	perceive physiological threats
2	Young not managing gentlemen	perceive psycho-sociological threats
3	R&D ladies	perceive threats to information
4	Middle-aged IT or production leaders	lack motivation, are under esteemed and perceive physical threats
5	Middle-aged office or customer service operators	perceive bad organization of work process and physical conditions at work

Source: authors' own study

7. Conclusion

Conduct of empirical studies of the self-assessment of occupational threats and the character of work by the knowledge workers by means of observable variables and application of one of the multidimensional exploratory techniques, cluster analysis, allowed to establish the following:

1. Occupational threats posed to knowledge workers were grouped into 4 logical items (clusters): "physiology" (P), "physical conditions" (F), "psycho-sociology" (S) and "data and autonomy" (D). Knowledge workers' perception covers mostly threats coming from physiology and psycho-sociology. Threats concerning physical conditions and threats to data security and lack of autonomy are perceived as relatively weak.
2. Knowledge workers were grouped into 5 clusters according to their perception of occupational threats. Cluster 1 covers employees „perceiving physiological threats", cluster 2 - „perceiving psycho-sociological threats", cluster 3 - „perceiving threats to information", cluster 4 - „lacking motivation, under esteemed and perceiving physical threats" and cluster 5 „perceiving bad organization of work process and physical conditions at work".
3. There are between cluster differences according to demographical variables and to the department and role in organization. Taking these characteristics into consideration cluster 1 can be defined as "young office leaders", cluster 2 – "young not managing gentlemen", cluster 3 - "R&D ladies", cluster 4 – "middle-aged IT or production leaders" and cluster 5 – "middle-aged office or customer service operators".
4. There are between cluster differences according to the assessment of the character of knowledge-based work. Taking this criterion into consideration, cluster 1 covers employees "education seeking and self-reliant", cluster 2 - "intensive IT-users", cluster 3 – "innovators", cluster 4 - "noticing no special features of work" they do and cluster 5 – "intellectualists".
5. Putting together results of study covering all of the research hypothesis and according to the clusters built to classify variables within the presented universe of discourse, it can be stated that:

a) According to the demographical and organizational variables versus the perception of the character of the knowledge based work: (1) young office leaders are education seeking and self-reliant, (2) young not managing gentlemen are intensive IT-users, (3) R&D ladies are innovators, (4) middle-aged IT or production leaders are noticing no special features of work and (5) middle-aged office or customer service operators are intellectualists.

b) According to the demographical and organizational variables versus the perception of occupational threats: (1) young office leaders perceive physiological threats, (2) young not managing gentlemen perceive psycho-sociological threats, (3) R&D ladies perceive threats to information, (4) middle-aged IT or production leaders lack motivation, are under esteemed and perceive physical threats and (5) middle-aged office or customer service operators perceive bad organization of work process and physical conditions at work.

The conclusions are of both cognitive and utilitarian character. In first case – the analysis revealed and explained the structure of perception of knowledge workers' occupational threats and the character of knowledge-based work, in second – the classification of variables allows to measure perception of occupational threats and use the results e. g. when designing trainings on occupational health and safety and to better fit them to this group of employees.

In the future research, a comparison of classification of variables with the use of different multidimensional exploratory techniques could bring interesting results.

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Małgorzata LOTKO
Aleksander LOTKO
Department of Economics
Kasimir Pulaski University of Humanities and Technology
ul. Chrobrego 31, 26-600 Radom, Poland
E-mails: m.lotko@uthrad.pl, aleksander.lotko@uthrad.pl