

Analysis of risk factors affecting occupational health and safety in textile firms in the framework of sustainability

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ABSTRACT – REZUMAT

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Determining risk factors affecting occupational health and safety is crucial for textile firms today. Identifying these risks helps firms assess their current situation and take stronger steps toward the future. In this study, the DEMATEL method was used to calculate the interactions and weighting of risk factors based on expert opinions, enabling a realistic and applicable occupational health and safety management approach. The analysis revealed that management perceptions, education, and employee expectations have the greatest impact on other criteria, while chemical factors are the most influenced by them. The criteria that do not significantly affect any of the criteria are employee psychology, biological factors, and technology. Implementing occupational health and safety practices while considering these factors will lead to more effective and efficient outcomes. Textile firms must prioritise such analyses and recognise their role in enhancing overall efficiency. Furthermore, firms that successfully foster an occupational health and safety culture will be better positioned to achieve their sustainability goals. By integrating these practices into their operational strategies, textile firms can create a safer and healthier environment for employees, ensure production continuity, and contribute to long-term growth and stability. Ultimately, understanding risk factors is key to aligning occupational health and safety with broader sustainability objectives, benefiting both firms and their stakeholders.

Keywords: textile industry, sustainability, occupational health and safety, DEMATEL method, risk factors

Analiza factorilor de risc care afectează sănătatea și siguranța la locul de muncă în întreprinderile textile în contextul sustenabilității

Determinarea factorilor de risc care afectează sănătatea și siguranța la locul de muncă este crucială pentru firmele textile în prezent. Identificarea acestor riscuri ajută firmele să își evalueze situația actuală și să ia măsuri mai ferme pentru viitor. În acest studiu, metoda DEMATEL a fost utilizată pentru a calcula interacțiunile și ponderarea factorilor de risc pe baza opiniilor experților, permițând o abordare realistă și aplicabilă a managementului sănătății și siguranței la locul de muncă. Analiza a relevat că percepțiile conducerii, educația și așteptările angajaților au cel mai mare impact asupra altor criterii, în timp ce factorii chimici sunt cei mai influențați de acestea. Criteriile care nu afectează în mod semnificativ sunt psihologia angajaților, factorii biologici și tehnologia. Implementarea practicilor de sănătate și siguranță la locul de muncă, luând în considerare acești factori, va conduce la rezultate mai eficiente și mai eficace. Firmele textile trebuie să acorde prioritate acestor analize și să recunoască rolul lor în îmbunătățirea eficienței generale. În plus, firmele care promovează cu succes o cultură a sănătății și securității în muncă vor fi mai bine poziționate pentru a-și atinge obiectivele de sustenabilitate. Prin integrarea acestor practici în strategiile lor operaționale, firmele textile pot crea un mediu mai sigur și mai sănătos pentru angajați, pot asigura continuitatea producției și pot contribui la creșterea și stabilitatea pe termen lung. În cele din urmă, înțelegerea factorilor de risc este esențială pentru alinierea sănătății și securității în muncă la obiectivele mai largi de sustenabilitate, aducând beneficii atât firmelor, cât și părților interesate.

Cuvinte-cheie: industria textilă, sustenabilitate, sănătate și securitate în muncă, metoda DEMATEL, factori de risc

INTRODUCTION

There is a consensus that the world's resources are approaching the limit of depletion due to human activities [1]. From an environmental perspective, sustainability can only be achieved by enabling the renewal of world resources. From a social perspective, it can be expressed as meeting the needs of today's human generation without harming the needs of future generations [2, 3]. From an economic perspective, it can be defined as addressing sustainable development, turning to renewable resources in production and being responsible for the environmental

impacts of production [3]. Considering the contributions of the textile sector to the income and employment created, it is of great importance for the sector to consider both the environmental, economic and social dimensions of sustainability. Sustainable production can only be achieved by adopting approaches that consider human health and safety while acting with environmental awareness.

Sustainability is vital for textile firms, especially in production activities. Beyond economic concerns, addressing labour issues, social needs, climate change, and pollution is crucial [4, 5]. Employee health

and safety are key components of sustainability, as healthy workers in safe environments form the foundation of sustainable production [4]. Occupational accidents and illnesses can lower productivity and firm performance [6]. Protecting employees' physical health and minimising work-related injuries are essential for sustainability. Therefore, firms must prioritise occupational health and safety measures to ensure long-term success and resilience [7]. Occupational health refers to the employee's ability to work in peace, free from risks posed by working conditions and equipment [8]. Occupational safety involves technical, medical, and legal measures to reduce or eliminate dangers, preventing physical and mental harm [9, 10]. Together, occupational health and safety aim to protect employees from adverse conditions, ensure workplace safety, maintain production continuity, and boost efficiency [11]. Both sustainability and occupational health and safety share a common goal: protecting and improving society, the economy, and the environment [12].

Many factors impact occupational health and safety in textile firms, including hazardous chemicals, noise, dust-related diseases, risks from machine parts, and non-ergonomic working styles [13]. Occupational accidents and physical illnesses related to ergonomics are more common in this sector [14]. Risk factors such as dust, temperature, humidity, noise, and lighting present significant dangers in the textile industry [15]. To prevent accidents, it's essential to analyse and address the underlying risk factors and take necessary precautions [16].

Özdemir identified garment-cutting workshops as having the poorest occupational health and safety conditions among textile facilities, followed by finishing and plain dye workshops [17]. Efe and Efe, analysing workplace accident records in a textile firm, found that 37% of accidents stemmed from ergonomic risks, rising to 95% when combined with psychosocial factors, emphasising the need for employee-focused environments to mitigate accidents [18]. Şener and Gülmez highlighted the importance of creating comfortable working conditions to boost employee motivation and production in ready-made clothing firms [19]. Bozkurt and Değirmenci addressed hazards and risks in the textile industry, relevant legislation, and associated practices [20]. Efe demonstrated that occupational accidents and illnesses caused by psychosocial and chemical risks significantly affect production, quality, and performance in the textile sector [21]. Efe and Efe emphasised the management-employer perception criterion as a critical factor influencing risk dynamics, with biological factors being the least impactful but most influenced [22]. Tatlıcan and Çöğenli examined job satisfaction levels in a textile firm, showing how occupational health and safety measures improve productivity [23]. Ağırhan noted that strict inspections under Law No. 6331 have increased employees' knowledge and awareness of occupational health and safety through mandatory training [24]. Çat et al. analysed risk evaluation forms, identifying "machinery,

work equipment, and hand tools" as the primary hazard criterion, with "moving-rotating parts" as the most critical sub-criterion [25].

Nowadays, the concept of sustainability is gaining importance in the textile and apparel sector. This sector can both directly and indirectly harm human health and the environment with its production processes and waste [26]. When literature is investigated, it is seen that there are studies analysing the risks of occupational accidents, but these studies do not examine the relationship between the field and sustainability. In this study, risk factors affecting occupational health and safety in the textile sector were examined first. Height risk factor criteria were determined because of literature research and expert opinions. Relationships and dependencies between the criteria were examined using the DEMATEL method, and dependent criteria weights were also calculated. Unlike other studies, the results were evaluated within the framework of sustainability. In this way, it was aimed to provide experts in the field of occupational health and safety with a different perspective and an effective perspective in evaluating risks.

MATERIAL AND METHOD

Data were collected using 8 risk factor criteria determined according to literature research [17, 22, 27] and expert opinions using face-to-face interview methods. A total of 40 experts were interviewed in 20 firms. Decision Making Trial and Evaluation Laboratory (DEMATEL) method, which is a multi-criteria decision-making method, was used in the analysis of the data. The DEMATEL method is expressed as studies aimed at developing a framework designed to identify the interdependent relationships of the elements in the mixed problem set and to prioritise the effects on each other within the scope of these determined relationships [28]. The steps of the DEMATEL method are as follows [29–31].

Step 1: Obtaining Direct Relationship Matrix: This matrix shows the relationships between the criteria in the pairwise comparisons made by experts. A scale consisting of the values 0, 1, 2, 3, 4, seen in table 1, is used for comparison [32].

In this step, experts are asked to answer the question "Level of influence between criteria?" according to the scale in table 1, and $k \times n$ dimensional direct relationship matrices are created according to the

Table 1

COMPARISON SCALE FOR DEMATEL METHOD	
Numerical value	Verbal expression
0	Ineffective
1	Low effective
2	Moderate effective
3	High effective
4	Very highly effective

evaluations of each expert. Each (i, j) element of this matrix shows the direct relationship from criterion i to criterion j . The average of the k direct relationship matrices obtained is taken using equation 1, and the average direct relationship matrix (X) is created using equation 2.

$$a_{ij} = \frac{1}{k} \sum_{n=1}^k x_{ij}^n \tag{1}$$

$$X = \begin{bmatrix} 0 & x_{11} & \dots & x_{1n} \\ x_{21} & 0 & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & 0 \end{bmatrix} \tag{2}$$

Step 2: Obtaining the Normalised Direct Relationship Matrix: The normalised direct relationship matrix (C) is obtained using equations 3 and 4.

$$s = maks (maks \sum_{j=1}^n x_{ij}, maks \sum_{i=1}^n x_{ij}) \tag{3}$$

$$C = \frac{X}{S} \tag{4}$$

Step 3: Obtaining the Total Relationship Matrix: Equations 5 and 6 are used to obtain the total relationship matrix (F).

$$\lim_{k \rightarrow \infty} c + c^2 + c^3 + \dots + c^k \tag{5}$$

$$F = C + C^2 + C^3 + \dots + C^k = C(I - C)^{-1} \tag{6}$$

Step 4: Determining Affected and Affecting Criteria Groups: Using the (F) matrix obtained in the previous step; the sum of the i^{th} row (Di) of this matrix shows the sum of the effects (direct and indirect) sent by the i th criterion to other criteria. The column sum (Rj) represents the sum of the effects coming from other criteria for the same criterion.

RESULTS AND DISCUSSION

In the first step of the study, the risk factors causing work accidents were determined, and then the results obtained by applying the DEMATEL method were interpreted within the framework of sustainability.

Step 1: Determination of Criteria and Obtaining the Direct Relationship Matrix: The risk factor criteria determined according to the literature research and expert opinions are given below. The average direct relationship matrix (X) is given in table 2.

1. Management Perceptions: Management's approaches and practices regarding occupational health and safety policies.
2. Employee Psychology: Situations such as stress, motivation, absent-mindedness, and mobbing.
3. Education: The education, knowledge, skills and experience that the employee receives regarding the job he/she does.

4. Employee Expectations: The demands and needs of the employees.
5. Biological Factors: Factors such as bacteria, viruses, parasites, fungi, etc.
6. Technology: The use of technologies that take into account the safety of the employee.
7. Chemical Factors: Factors such as explosive, flammable, combustible, poisonous, suffocating, and irritating.
8. Physical Factors: Factors such as noise, lighting, thermal comfort, vibration, etc. In addition, the movements of the employee such as heavy lifting, reaching, pulling, and standing for long periods of time.

Table 2

DIRECT RELATIONSHIP MATRIX								
X	K1	K2	K3	K4	K5	K6	K7	K8
K1	0	4	4	3	4	3	4	4
K2	2	0	2	2	3	2	1	2
K3	4	3	0	3	3	4	4	3
K4	3	4	4	0	2	3	4	3
K5	3	1	2	1	0	2	3	2
K6	3	3	2	1	3	0	3	2
K7	2	3	4	4	4	3	0	2
K8	2	3	2	4	3	3	4	0

Step 2: Obtaining the Normalised Direct Relationship Matrix: table 3 provides the normalised direct relationship matrix.

Step 3: Obtaining the Total Relationship Matrix: The total relationship matrix is given in table 4.

To interpret the findings, the average of all figures was taken, and the resulting value of 0.417 was determined as the threshold value. Values above this value were considered significant, while values below were considered insignificant.

It was determined that the criteria with the highest impact on other criteria were K1 management perceptions, K3 training and K4 employee expectations (table 4). Accidents can be prevented, and management must take responsibility for this. What is important in occupational health and safety is not individual action but collective action in accordance with the

Table 3

NORMALIZED DIRECT RELATIONSHIP MATRIX								
C	K1	K2	K3	K4	K5	K6	K7	K8
K1	0	0.15385	0.1538	0.1154	0.15385	0.1154	0.15385	0.154
K2	0.0769	0	0.0769	0.0769	0.11538	0.0769	0.03846	0.077
K3	0.1538	0.11538	0	0.1154	0.11538	0.1538	0.15385	0.115
K4	0.1154	0.15385	0.1538	0	0.07692	0.1154	0.15385	0.115
K5	0.1154	0.03846	0.0769	0.0385	0	0.0769	0.11538	0.077
K6	0.1154	0.11538	0.0769	0.0385	0.11538	0	0.11538	0.077
K7	0.0769	0.11538	0.1538	0.1538	0.15385	0.1154	0	0.077
K8	0.0769	0.11538	0.0769	0.1538	0.11538	0.1154	0.15385	0

Table 4

TOTAL RELATIONSHIP MATRIX								
F	K1	K2	K3	K4	K5	K6	K7	K8
K1	0.3967	0.56284	0.5491	0.4812	0.59115	0.518	0.60127	0.509
K2	0.296	0.24007	0.3034	0.2801	0.35944	0.3038	0.303	0.283
K3	0.508	0.50954	0.3929	0.458	0.53465	0.5251	0.57505	0.457
K4	0.4632	0.52693	0.5129	0.3443	0.48702	0.4809	0.55715	0.443
K5	0.3364	0.29172	0.3176	0.2624	0.27094	0.3158	0.38029	0.292
K6	0.3696	0.39072	0.3506	0.2918	0.41343	0.2773	0.41552	0.323
K7	0.416	0.47102	0.4918	0.4549	0.52413	0.4598	0.40174	0.393
K8	0.3974	0.45785	0.4161	0.4453	0.47799	0.4438	0.51864	0.307

rules [24]. Therefore, the management's approaches and practices regarding occupational health and safety policies are very important. It has been shown in other studies that management perceptions are an important factor in the effectiveness of occupational health and safety practices. Occupational health and safety practices should not be seen as a financial loss, but as an element that will provide an advantage with its economic return in the competitive environment [22]. When occupational health and safety management is poor, corporate culture, safety culture and firm performance will be negatively affected by this situation [33]. The general level of education of employees in textile firms is low. This situation requires more intensive training activities to develop the occupational health and safety awareness of employees and to apply what is learned. Especially the high number of technical employees requires more technical education and occupational health and safety training [11]. All problems arising from the workplace environment can be solved through training [34]. It is a fact that this training will be more efficient with employees whose demands and needs are met. It is important to determine and eliminate all factors that have a negative effect on the health and safety of employees [22]. Regulations regarding occupational health and safety are included in the legislation, and the greatest responsibility for contributing to these regulations falls on employers, followed by employees [20].

The criterion most affected by management perceptions was determined as chemical factors (0.601), the criterion most affected by training was determined as chemical factors (0.575), and the criterion most affected by employee expectations was determined as chemical factors (0.557). The criteria that did not significantly affect any criteria were K2 employee psychology, K5 biological factors and K6 technology. The criteria with the highest impact were the chemical factors that were most affected. It is thought that this situation is because most of the firms from which the data was obtained are finishing firms. It is thought that physical factors may also come to the fore if the number of weaving and yarn firms is high. It has been concluded that for sustainable production, it would be a more realistic approach

to conduct risk factor analyses with multi-criteria decision-making methods such as DEMATEL according to the type of production. The criteria most affected by other criteria were determined as K2 employee psychology, K5 biological factors and K6 technology (table 4). It was observed that the criterion that affects employee psychology the most is management perception (0.562), the criterion that affects biological factors the most is management perception (0.591),

and the criterion that affects technology the most is education (0.525).

Step 4: Determining Affected and Affecting Criteria Groups.

Table 5 shows the degree of influence and being influenced by the criteria. Accordingly, the criterion that is most related to other criteria and has the highest effectiveness in the system is management perceptions, with a value of 7.39. This criterion is followed by chemical factors with a value of 7.36. However, the criterion that has the least relationship density with other criteria and has the lowest effectiveness in the system is the employee psychology criterion, with a value of 5.81.

Table 5

INFLUENCING AND BEING INFLUENCED BY CRITERIA				
	Di	Rj	Di+Rj	Di-Rj
K1	4.2089	3.18314	7.3921	1.0258
K2	2.3683	3.4507	5.819	-1.082
K3	3.96	3.33449	7.2945	0.6255
K4	3.8158	3.01821	6.834	0.7976
K5	2.4677	3.65876	6.1264	-1.191
K6	2.8321	3.32453	6.1566	-0.492
K7	3.6123	3.75266	7.365	-0.14
K8	3.4636	3.00631	6.4699	0.4573

When the D-R value is examined, the direction of the relationship of the criteria is obtained. It is seen that the degree of influence of the criteria with positive D-R values on other criteria is greater than the degree of being influenced (table 5). Accordingly, the criteria with a greater degree of influence than the degree of being influenced are K1 management perceptions (1.02>0), K4 employee expectations (0.79>0), K3 education (0.62>0), and K8 physical factors (0.45>0), respectively. The degree of being influenced by other criteria with negative D-R values is greater than the degree of influencing. Among these, the criteria with the highest degree of impact are K5 biological factors with a value of -1.19, K2 employee psychology with a value of -1.08, K6

technology with a value of -0.49 , and K7 chemical factors with a value of -0.14 .

CONCLUSIONS

In this study, risk factors affecting occupational health and safety in the textile sector were evaluated within the framework of sustainability. The data obtained using 8 criteria determined according to literature research and expert opinions were analysed using the DEMATEL method, one of the multi-criteria decision-making methods. As a result of the research, it was seen that the criteria that had the most impact on others were management perceptions, training and employee expectations. It was concluded that more efficient results would be obtained if occupational health and safety studies were carried out by taking these factors into consideration.

The most influential criterion in the system was identified as management perceptions. Ensuring the efficiency of occupational health and safety practices primarily depends on management perceptions. Management should not perceive these practices as a financial burden but as a competitive advantage and a necessity for a sustainable economy. A safe work environment increases employee motivation [35], enhances productivity, and reduces occupational health and safety-related costs, leading to economic gains [36]. Poor occupational health and safety management negatively impacts firm performance [37]. Other important factors in ensuring the efficiency of occupational health and safety practices have been determined as training and employee expectations. Training employees and efforts to eliminate situations such as fatigue and uninterrupted work will significantly affect the efficiency of the firm. When we look at the working and rest periods, we see that the rest periods are quite short in comparison. Considering these needs during planning will contribute to the physical and mental rest of the employee [18]. Improving working conditions, providing training to employees, improving strategic decisions based on employee health and safety, and conducting workplace controls to reduce risks contribute to sustainability [4]. For occupational health and safety practices in firms to be sustainable, improvements are required in some areas, such as minimising work accidents, reducing or eliminating occupational diseases, developing occupational health and safety management systems, and ensuring employee participation. Management focused on occupational health and safety results in sustainable development [38].

The criteria most influenced by management perceptions, education, and employee expectations were identified as chemical factors, likely because 16 of the 20 firms in the study are dyehouses. If the included firms were spinning or weaving mills, physical factors might have had a greater impact. For instance, an expert in a dyehouse may prioritise chemical risks, whereas an expert in a weaving mill might focus more on physical risks. Thus, analysing risk

factors individually for each stage of textile production is essential for sustainable operations. The criteria most affected by other factors were found to be employee psychology, biological factors, and technology. The physical and mental integrity of employees, who are the most valuable assets in maintaining production and efficiency, must be protected.

Adopting, implementing, and sustaining an occupational health and safety management approach is key to achieving this. Fostering awareness of occupational health and safety and establishing a safe, healthy working environment reflects a firm's perspective on employee value. Firms should prioritise health and safety in all aspects, from equipment and infrastructure to processes, using technologies that enhance employee safety. When firms view occupational health and safety expenses not as costs but as investments, they achieve sustainability [39].

Cultivating a safety culture also enables firms to thrive in competitive environments [4]. Economic efficiency, which is one of the principles underlying sustainability that requires an integrated approach, is directly proportional to competitiveness.

Today, determining the risk factors affecting occupational health and safety has become a very important issue for textile firms. Determining the risks that negatively affect the health and safety of employees will enable firms to see their current situation and thus reach the future with more solid steps. Understanding risk factors is the first step in aligning occupational health and safety with sustainability goals. Risk factors and importance levels are different for each sector and field of work. Conducting occupational health and safety studies by considering the weights between the factors determined according to different areas of the textile industry will provide more efficient and effective results. Textile firms should attach importance to such analyses conducted to determine the risk factors affecting occupational health and safety and should see these analyses as a means of increasing efficiency. Sustainable production will only be possible in this way.

The fact that this research was conducted with 16 finishing and 4 weaving companies from the textile sector is one of the limitations of the research. Because the criteria and their weights may differ depending on the field of study. Therefore, the results obtained are general and are a guide for the studies to be conducted in this field. It is thought that in future studies, grouping field-based studies such as yarn, weaving, finishing, and determining and weighting criteria will make occupational health and safety practices much more effective. There are also some potential limitations of the DEMATEL method. The method is based on the opinions of the evaluator. The subjective perspectives of the evaluators may affect the accuracy of the method. Considering this situation, the evaluators were selected from experts who are knowledgeable in the field, and an objective evaluation was tried to be made. However, for larger-scale problems with many criteria and factors, the DEMATEL matrix can be quite complex and difficult to analyse. DEMATEL

analyses relationships over a certain time. However, if there are dynamics that change over time in the system, the model needs to be updated. To over-

come these limitations, it is considered that DEMATEL will be supported with artificial intelligence-supported analyses in future studies.

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