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Research Article

Evaluation of Issues Caused by Work Accidents by AHP and DEMATEL Methods

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Keywords
Analytical Hierarchy Process (AHP) method, DEMATEL method, Cause-effect relationship in Work Accidents.

Abstract
Work accidents are one of the biggest problems of the industrial industry today. Although protective and preventive practices were tried to be implemented, the desired numerical ratios could not be reached. Employees are often adversely affected by many factors that can be created by factors such as machinery, people and the environment in the process of fulfilling their job acquisitions. For example, many issues such as thermal comfort, labor, production methods, sabotage, cyber attacks, earthquakes and floods are among the risk groups that can be taken into account in this context. Occupational accidents, when, how and where they may occur can often be predicted by risk analyzes made by experts. This can be achieved by clearly foreseeing the risks and applying the right analysis method to these risks. In this study, the issues that cause occupational accidents to occur were tried to be determined by the Analytical Hierarchy Process (AHP) method and Dematel methods. The criteria and sub-criteria used in the analysis were formed by taking expert opinions. In the study, attention was paid to the fact that there are factors that cause the occurrence of occupational accidents and are based on the cause-effect relationship. The analysis consists of four main criteria: production methods (K-1), costs (K-2), risks (K-3) and legal regulations (K-4). Sub-criteria (A.K.) were determined as A.K.-1 death rates, A.K.-2 injury rates, A.K.-3 near misses, A.K.-4 unacceptable risks. As a result of the analysis made among the main criteria, the consistency ratio was found to be 0.1 >0.0907. According to this result, the criterion with the highest weight among the main criteria was K-3 other factors (human, physical factors, ergonomics, psycho-social factors, etc.). As a result of the analysis using the Dematel method, the criterion with the highest D+R value was the legal regulations. According to this result, legal regulations have been interpreted as having a decisive effect on other criteria. The criterion with the highest D-R value was other factors. According to this result, it has been interpreted as being affected by the production method and cost criteria, other elements and legal regulations.

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İş Kazasına Neden Olan Hususların AHP ve DEMATEL Yöntemleri İle Değerlendirilmesi

Anahtar Kelimeler
Analitik Hiyerarşi Proses (AHP) yöntemi, DEMATEL yöntemi, İş Kazalarında sebep-sonuç ilişkisi.

Özet
İş kazaları, günümüzde endüstriyel sanayinin en büyük sorunlarından bir tanesidir. Her ne kadar koruyucu ve önleyici uygulamalar hayata geçirilmeye çalışılsa istenilen sayısal oranlara ulaşılabilmiş değildir. Çalışanlar, iş edinimlerini yerine getirme süreçlerinde makine, insan ve çevre gibi unsurların yaratabileceği birçok etkenden çoğu kez olumsuz etkilenirler. Örneğin, termal konfor, işgücü, üretim metotları, sabotaj, siber saldırı, deprem, sel gibi birçok husus bu kapsamda dikkate alınabilecek risk gruplarındandır. İş kazaları, ne zaman, nasıl ve nerede ortaya çıkabileceği çoğu zaman uzman kişiler tarafından yapılan risk analizleri ile öngörülebilir. Bu da risklerin net olarak öngörülmesi ve bu risklere doğru analiz yönteminin uygulanmasıyla sağlanabilir.
Bu çalışmada, iş kazalarının ortaya çıkmasına neden olan hususlar Analitik Hiyerarşi Proses (AHP) yöntemi ve Dematel yöntemleri ile belirlenmeye çalışılmıştır. Analizde kullanılan kriter ve alt kriterler uzman görüşleri alınarak oluşturulmuştur. Yapılan çalışmada iş kazalarının ortaya çıkmasında neden olan ve sebep-sonuç ilişkisine dayanan unsurların olmasına dikkat edilmiştir. Analizde, üretim yöntemleri (K-1), maliyetler (K-2), riskler (K-3) ve yasal düzenlemeler (K-4) olmak üzere başlıca dört kriterden oluşmaktadır. Alt kriterler ise (A.K.) ise, A.K.-1 ölüm oranları, A.K.-2 yaralanma oranları, A.K.-3 ramak kala olayları, A.K.-4 kabul edilemez riskler olarak belirlenmiştir. Ana kriterler arasında yapılan analiz sonucunda tutarlılık oranı 0,1 >0,0907 bulunmuştur. Bu sonuca göre ana kriterler arasında en yüksek ağırlığa sahip kriter K-3 diğer unsurlar (insan, fiziksel etkenler, ergonomi, psiko-sosyal etkenler vb.) olmuştur. Dematel yöntemi kullanılarak yapılan analiz sonucunda ise D+R değeri en yüksek kriter yasal düzenlemeler olmuştur. Bu sonuca göre yasal düzenlemeler diğer kriterler üzerinde belirleyici etkiye sahip olduğu şeklinde yorumlanmıştır. D-R değeri en yüksek kriter ise diğer unsurlar olmuştur. Bu sonuca göre, üretim yöntemi ve maliyet kriterleri, diğer unsurları ve yasal düzenlemeler tarafından etkilendiği şeklinde yorumlanmıştır.

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1. Introduction

The increase in human needs day by day has led to the rapid evolution of many phenomena, especially production technologies. For example, it has revealed a new understanding of production by using technologies such as automation systems, fully mechanized systems and the internet of things in the industry. While the change experienced in the industrial industry has increased the quality and production speed, it has also reduced the waste of raw materials and energy. This is a great advantage for many businesses that keep up with the process. However, these aspects alone are not enough for an enterprise to have a sustainable production approach. At this point, it is of great importance to identify the risks that employees may be exposed to in the business ecosystem and to provide a safe working environment. According to the data of the International Labor Organization (ILO), as of 2017, there are approximately 3 billion workforce in the world, 1.2 billion of which are female workers. Almost every day, 1 million occupational accidents occur. About 2.3 million employees die every year as a result of work accidents and occupational diseases. More than this number becomes incapacitated. This situation corresponds to approximately 4% of the gross national product (GNP) worldwide (Bilir, 2016; 4). As it can be understood

from the numerical data, it is seen that occupational accidents do not constitute a particular social area but a global problem. Occupational accidents are the physical or mental harm that employees face when they are about to fulfill their job acquisitions. According to the ILO, an occupational accident is defined as "an unexpected, previously unplanned event that causes specific injury or damage". As stated in the human rights declaration, the most basic rights of people are stated as living, freedom, fair and appropriate working conditions (SGK, 2019; TUIK 2019, Irmak et al. 2021). Although national and international agreements, laws and regulations regarding occupational safety have been enacted, the desired level of occupational accident rates has not been achieved. In Turkey, a number of legal regulations have been implemented, both at the international (WHO, ILO) and national level, for work accidents and occupational diseases. For example, within the scope of the legal regulations regarding occupational safety, the Labor Law No. 4857 (2003), the Law No. 5510 (2006), the Vocational Qualification Directive (M.Y.Y.-2007) and the Occupational Health and Safety Law No. 6331 were enacted.These regulations are intended to protect employees against work accidents and occupational diseases. However, considering the work accidents that have occurred in our country recently, it is seen that the effect of the legal regulations on the work safety culture is not at the desired level. For example, after the Labor Law No. 4857 (2003), in the mining sector, which is one of the most dangerous business lines; Aşkale (2003) 8, Ermenek (2003) 10, Bayat (2004) 3, Küre (2004) 19, Gediz (2005) 18, After Law No. 5510 (2006); Dursunbey (2006) 17, M.Y.Y. (2007) after; M. Kemalpaşa (2009) 19, Dursunbey (2010) 13, Karadon (2010) 30, Elbistan (2011) 11, After Law No. 6331 (2012); Kozlu (2013) 8, Soma (2014) 301, Ermenek (2014) 18, Şirvan (2016) 16, Şırnak (2017) 7, Milas (2019) 3, Soma (2020) 3 mine workers lost their lives (Chamber of Mining Engineers, 2020:19). When the statistics of work accidents and occupational diseases in Turkey are examined, 359,866 work accidents occurred in 2017, 1636 employees, while 430.985 work accidents occurred in 2018, 1541 employees, and in 2019 422,463 work accidents, 1147 employees lost their lives (Gözüak and Ceylan, 2021: 140). There are many factors such as social, economic and cultural in the emergence of occupational accidents. A comprehensive examination and analysis of the causes of occupational accidents is of great importance at this point. This study was carried out in order to deal with the issues that cause occupational accidents within the scope of cause and effect relationship. In the study, Analytical Hierarchy Process (AHP) method and Dematel methods from Multi-Criteria Decision Making (MCDM) methods were used. The criteria and sub-criteria used in the study were selected by taking expert opinions. Microsoft Excel was used to solve the analysis. There are many studies in the literature using AHP and Dematel methods. Saçak et al. (2019) analyzed the applications of the Internet of Things in businesses with AHP and Dematel methods. Çelik and Çağıl (2021) applied the supplier selection in a tractor factory using fuzzy MCDM methods. Erdal (2019) proposed a new approach by adapting occupational health and safety to Dematel and Aras-based risk assessment methodology. Kantoglu et al. (2019) applied the AHP model in occupational health and safety education. Gül et al. (2018) used the fuzzy AHP and Fuzzy Vıkor methods to weight the risks in the occupational health and safety risk assessment method. Janackovic et al. (2013) conducted a study that

determined occupational safety factors, performance indicators and measurements with the fuzzy AHP method model. Aydın (2019) evaluated OHS-related problems in a private hospital using the AHP method. Aksakal and Dağdeviren (2013) solved the personnel selection problem with an integrated approach using ANP and DEMATEL methods. In the literature search, no study based on cause and effect relationship was found using AHP and Dematel methods. It is expected that this study will make a significant contribution both to the prevention of occupational accidents and to the literature.

2. Metodology

2.1. AHP Method

The AHP method was introduced by Alpert and Mayers in 1968. It was developed as a model by Thomas Loric Saaty in 1970 and made it usable in decision-making problems (Yaralıoğlu, 2001). AHP is an approach that combines experience, knowledge, experience and intuition (Saaty & Vargas, 1987). The most important problem in Multi-Criteria Decision-Making problems is weight, superiority or importance in order to choose the best one among multiple alternatives. At this point, the AHP method is one of the MCDM methods used to solve these problems. AHP is a method that can include both the objective and subjective thoughts of the participants in the decision phase (Gülenç & Bilgin, 2010:98). The first step in the AHP method is to determine a decision problem in line with the goal of the decision maker. The criteria, sub-criteria and alternatives that reveal this problem are determined.Thus, the solution hierarchy of the analysis emerges. Comparison matrix is obtained by making pairwise comparisons between the items. In other words, two factors are compared with the pairwise comparison. This situation is based on the personal foresight of the decision makers. Each criterion is then prioritized according to its importance. At the last stage, the most appropriate decision alternative is determined by considering all the criteria (Saaty, 2001). The steps to be followed in the solution of the AHP method are as follows.

Table 1. Binary Comparison Scale (Saaty, 1977:246)

Degrees	Row/Column Numeric Value	Definition
1	1	Equally Important
3	1/3	A Little More Important
5	1/5	Strongly Important
7	1/7	Very Strongly Important
9	1/9	Extremely Important
2-4-6-8	Intermediate Values	Compromise (Average) Values
If a value (x) is assigned when comparing reciprocal values i,j; The value to be assigned when comparing with j,i will be (1/x).		

$$a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{1}$$

In the first stage, the structure of the hierarchy is created. In the second stage, a pairwise comparison matrix is created by considering the comparison scale in Table 1. Equation 1 is used for this operation.

i=1,2,3,….n ve j=1,2,3,…..n

$$w_i = \left(\frac{1}{n}\right)\sum_{j=1}^{n} a'_{ij} \tag{2}$$

In the third step, the normalization process is performed using the equation numbered 2.

$$CR = \frac{CI}{RI} \tag{3}$$

In the fourth stage, the consistency index is checked. Equation 3 is used for this operation. For the operation to be consistent, it should be 0.1> CR (Saaty, 1980).

2.2. DEMATEL Method

DEMATEL is a method used in the solution of MCDM methods. This method was first introduced by the Geneva Battelle Memorial Institute, Science and Human Relations program between 1972 and 1976, to be used in solving difficult and complex problems (Fontela and Gabus, 1974; Li and Tzeng, 2009; Aksakal and Dağdeviren, 2013). The Dematel method is a MCDM method used to reveal the relationships between criteria clearly. With this method, the interaction between the criteria, whether a criterion is affected by another criterion or by other criteria can be found (Çelikbilek, 2018). The Dematel method benefits from the knowledge and experience of experts in designing a structural model (Liou et al., 2008). The most important advantage of this method is that it covers indirect relationships with a compromised cause-effect model. It is an important method that examines the relationships between the components of the method, the structure or the alternatives at the current level. With the DEMATEL method, the criteria can be arranged in order of priority by examining the relationships, gender and the effects on each other (Tseng and Ling, 2008). The steps to be followed in the solution of the method are briefly mentioned below.

Step 1: Direct relationship matrix is created.

In the analysis, the opinions of the participants are taken in order to obtain the interaction between the criteria.

In the comparison, the effect of each criterion i on the criterion j is calculated. A 0-4 comparison scale (Table 2) is used to measure the effect of criteria on each other.

Table 2. The Criterion Significance Scale Used in the DEMATEL method

Comparasion Scala
0= Ineffective
1= Low Impact
2= Medium Impact
3= High Impact
4= Very High Impact

Step 2: The normalized direct matrix (M) is obtained by using the smallest value (k) of the column and row by using the equation 1 and 2, which is formed depending on the direct relationship matrix (A). The diagonal values of matrix A are 0 (Aksakal and Dağdeviren, 2010).

$$M = k \times A \tag{1}$$

$$k = \text{Min.}\left(\frac{1}{max\sum_{j=1}^{n} a_{ij}}\right)\left(\frac{1}{max\sum_{j=1}^{n} a_{ij}}\right) \tag{2}$$

$i, j \in \{1,2,3,\ldots,n\}$

Step 3. After the 2nd step, the total relationship matrix S (equation 3) is obtained. One matrix used in the equation is expressed as I (Tsai and Chou, 2009; Hung et al., 2006). The unit matrix is expressed as (I) in this equation.

$$S = M + M^2 + M^3 + \ldots = \sum_{j=1}^{\infty\leftarrow} M\text{^}i = M\,(I-M)^{-1} \tag{3}$$

Step 4. After the total relationship matrices are created, R and D values are calculated to determine the relationship and interaction levels. Finally, D-R and D+R values are calculated (equation 4.5 and 6), and the results are evaluated (Tsai and Chou, 2009; Hung et al., 2006; Saçak et al., 2019).

$$S = [Si, j]_{nxn} \qquad i,j \in \{1,2,3,\ldots,n\} \tag{4}$$

$$D = \sum_{j=1}^{n} S\dot{I}, J \tag{5}$$

$$R = \sum_{j=1}^{n} S\dot{I}, J \tag{6}$$

D+R values show the interaction of each criterion with the others. While the criterion with positive and high value obtained as a result of the calculation is more related to other criteria, the effect of the lower ones is considered less (Tsai and Chou, 2009; Seyed et al., 2005).

3. Application

The rapid change in the industrial industry has caused many phenomena to be affected in different ways. This change is expected to deeply affect not only production methods, but also cost, legal regulations, production safety (business, environment and people) and many other factors. Multiple factors can cause occupational accidents in the workplace. There are many studies with this content in the literature. However, no study was found that used the AHP and DEMATEL methods and included the criteria and sub-criteria created by taking expert opinions. For this reason, at the end of the study, which criterion or criteria affect the sub-criteria and how much is the aim of the study at this point. The study was analyzed using AHP and its methods. Microsoft Excel was used to solve the analysis.

3.1. Analysis of AHP Method

Each criterion and sub-criteria used in the AHP analysis were compared among themselves and consistency indexes were calculated. Below are the solutions and other information obtained from the analysis of the method. Abbreviations used in analysis; Main Criteria (K.), Criterion-1: Production Methods, Criterion-2: Costs, Criterion-3: Other Elements (human, physical factors, ergonomics, psycho-social factors), Criterion-4: Legal Regulations. Sub-Criteria, (AK-1): Mortality Rates, EC-2: Injury Rates, EC-3: Near-Miss Events, EC-4: Unacceptable Risks

The results of the analysis using the AHP method are given below.

As a result of the comparison between the criteria in Table 1,2,3 and 4; normalized matrix, all priorities vector calculation and consistency indexes were calculated.

Table 1. The Criterion Used in Pairwise Comparison

	K-1	**K-2**	**K-3**	**K-4**
K-1	1	1,0626	0,6082	0,3684
K-2	0,9411	1	0,3915	1,3389
K-3	1,6442	2,5543	1	2,0801
K-4	2,7144	0,7469	0,4808	1
Total	**6,2997**	**5,3638**	**2,4805**	**4,7874**

Table 2. Normalized Matrix

	K-1	**K-2**	**K-3**	**K-4**	**Criterion Weights (W)**
K-1	0,1587	0,1981	0,2452	0,0769	0,1697 **(4)**
K-2	0,1493	0,1864	0,1578	0,2797	0,1933 **(3)**
K-3	0,2611	0,4762	0,4032	0,4345	0,3938 **(1)**
K-4	0,4309	0,1393	0,1938	0,2089	0,2432 **(2)**
Total	**1**	**1**	**1**	**1**	**1**

Table 3. All Priorities Vector Calculation

	K-1	K-2	K-3	K-4	Total
K-1	0,1697	0,2054	0,2395	0,0896	0,7042
K-2	0,1597	0,1933	0,1542	0,3256	0,8328
K-3	0,2790	0,4937	0,3938	0,5059	1,6724
K-4	0,4606	0,1444	0,1893	0,2432	1,0375

Table 4. Consistency Index

Total	**Criterion Weights (W)**	**T/W**	**Average**	**Lamda Max.**
0,7042	0,1697	4,1419	4,2407	Consistency İndeks
0,8328	0,1933	4,3083		0,08025
1,6724	0,3938	4,2468		Rassal İndex
1,0375	0,2432	4,2660		0,885/ (RI)
Total		16,9628		**0,1** >0,0907

Production Method: In Table 5, the normalized matrix, all priorities vector calculation and consistency indexes were calculated among the sub-criteria (death rates, injury rates, near misses and unacceptable risks) created under the title of production method main criteria.

Table 5. Normalized Matrix

Sub-Criteria (A.K.)	**Sub-Criteria Weights (W)**	**Consistency Index**
A.K.-1	0,1930	0,1 >0,06900
A.K.-2	0,1268	
A.K.-3	0,2697	
A.K.-4	0,4105	
Total	1	

Cost: In Table 6, the normalized matrix, all priorities vector calculation and consistency indexes were calculated among the sub-criteria (death rates, injury rates, near misses and unacceptable risks) created under the heading of cost main criteria.

Table 6. Normalized Matrix

Sub-Criteria (A.K.)	**Criteria Weights (W)**	**Consistency Index**
A.K.-1	0,2540	0,1 >0,0103
A.K.-2	0,1643	
A.K.-3	0,2558	
A.K.-4	0,3259	
Total	1	

Other Elements: In Table 7, the normalized matrix, all priorities vector calculation and consistency indexes were calculated among the sub-criteria (death rates, injury rates, near misses and unacceptable risks) created under the other elements main criteria title.

Table 7. Normalized Matrix

Sub-Criteria (A.K.)	Criteria Weights (W)	Consistency Index
A.K.-1	0,2566	0,1 >0,0316
A.K.-2	0,2439	
A.K.-3	0,2724	
A.K.-4	0,2271	
Total	1	

Legal Arrangements: In Table 8, the normalized matrix, all priorities vector calculation and consistency indexes were calculated among the sub-criteria (death rates, injury rates, near misses and unacceptable risks) created under the other elements main criteria title.

Table 8. Normalized Matrix

Sub-Criteria (A.K.)	Criteria Weights (W)	Consistency Index
A.K.-1	0,2063	0,1 >0,0545
A.K.-2	0,1749	
A.K.-3	0,2902	
A.K.-4	0,3286	
Total	1	

As a result of the analysis using the AHP method, the consistency ratio of the calculation result between the criterion and the sub-criteria related to each criterion was lower than 0.1>. Accordingly, the criterion with the highest weight was 0.3938 and other factors (human, physical factors, ergonomics, psycho-social factors, etc.).While 0.2432 legal regulations were the second highest weighted criterion, it was followed by 0.1933 cost and 0.1697 production methods, respectively.

3.2. Analysis of the DEMATEL Method

In the DEMATEL method, only the main criteria are included in the analysis, unlike the AHP method. In the method used, the main criteria of K-1: production method, K-2: Cost, K-3: Other Elements, K-4: Legal Regulations were analyzed.

Table 1. Evaluation Table of Main Criteria

Criteria	K-1	K-2	K-3	K-4
K-1	0	4	3	3
K-2	2	0	1	4
K-3	4	2	0	4
K-4	4	3	4	0

In Table 1, the direct relationship matrix created by taking into account the answers given by the participants included in the study is given.

Table 2. Directly Related Matrix for Main Criteria (X)

	K1	K2	K3	K4	Total
K1	0	4	3	3	10
K2	2	0	1	4	7
K3	4	2	0	4	10
K4	4	3	4	0	**11**
Total	10	9	8	**11**	

Direct Relationship Matrix was formed by taking the arithmetic average of each value given by the participants in Table 2. In the direct relationship matrix, the maximum value is determined by taking the sum of each row and column. According to this, the highest values for the row and column were the K-4 criterion with 11. Then each row is divided by this value and the normalized matrix is obtained (Table 3).

Table 3. Normalized Direct Relationship Matrix

Criteria	K-1	K-2	K-3	K-4	Total
K-1	0	0,36	0,27	0,27	10
K-2	0,18	0	0,18	0,36	7
K-3	0,36	0,18	0	0,36	10
K-4	0,36	0,27	0,36	0	11

After obtaining the direct relationship matrix, the total relationship matrix is obtained by using the equation number 3 (Table 4).

Table 4. Total Relationship Matrix

					D (Row Totals)
	1,735956	1,870614	1,819606	2,067187	7,493364
	1,645758	1,3687	1,536847	1,850352	6,401656
	2,063107	1,80659	1,661872	2,165685	7,697254
	2,172017	1,963343	2,028281	2,023429	8,18707
R (Column Totals)	7,616838	7,009247	7,046606	8,106653	

After obtaining the total relationship matrix, using equations 5 and 6 (D and R values) influencing and affected factor groups are obtained. While D+R value is obtained by adding each criterion in the calculation, D-R values are obtained by subtraction for each criterion (Table 5).

Table 5. Affecting and Affected Factor Groups

Criteria	D	R	D+R	D-R
K1: Production Method	7,493364	7,61684	15,1102	-0,12348
K2: Cost	6,401656	7,00925	13,41091	-0,60759
K3: Other Elements	7,697254	7,04661	14,74386	0,65064
K4: Legal regulations	8,18707	8,10665	16,29372	0,08042

The result obtained from the D+R calculation shows us how important the criteria are. It gives the relationship between each criterion and other criteria. The highest value is interpreted as the value with the highest effect on other criteria. In other words, legal regulations (K-4) can be interpreted as having the most decisive and most relevant effect on other criteria. When the results obtained from the D-R calculation are compared, the criteria with positive values here affect the other criteria. Negative criteria are affected by positive criteria. According to the results of the analysis, the production method (K-1) and cost criteria (K-2) affect other elements (K-3) and legal regulations (K-4). In Figure 1, the distribution chart of the criteria affecting and affected as a result of the analysis according to the threshold value is given.

Figure 1. The scatter plot of the criteria

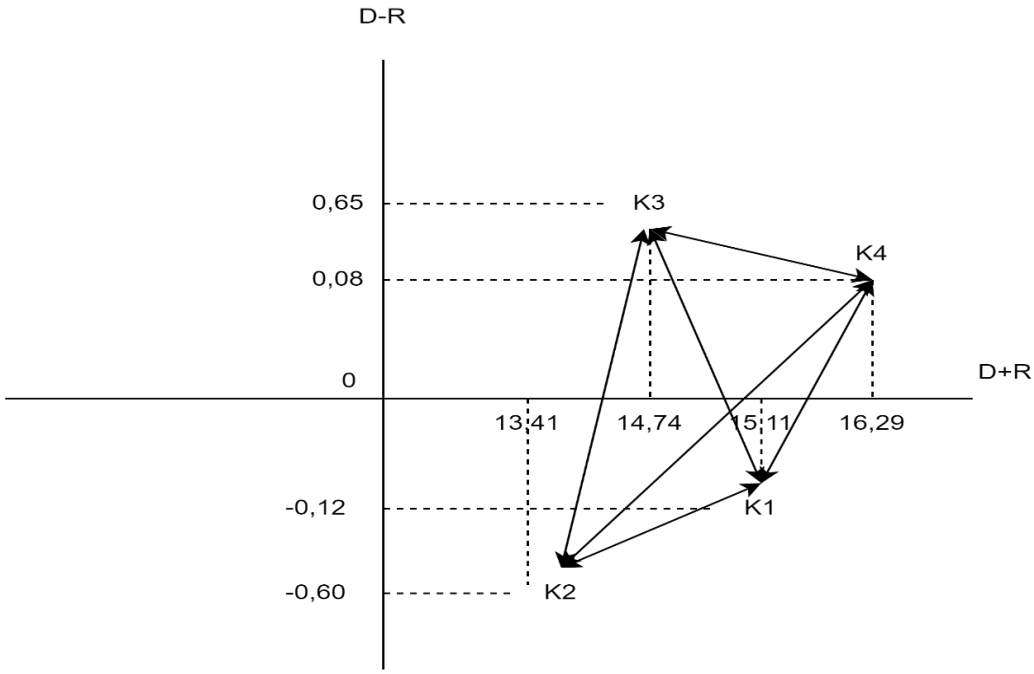

Table 10. AHP and DEMATEL Analysis Results

Kriterler	Criterion Weights (W)	D and R Values		D+R	D-R
K-1: Production Method	0,1697 (4)	7,493364	7,61684	15,1102	-0,12348
K-2: Cost	0,1933 (3)	6,401656	7,00925	13,41091	-0,60759
K-3: Other Elements	0,3938 (1)	7,697254	7,04661	14,74386	0,65064
K-4: Legal regulations	0,2432 (2)	8,18707	8,10665	16,29372	0,08042

Table 10 shows the analysis results obtained from the AHP and DEMATEL methods. As a result of the analysis made among the main criteria using the AHP method, the highest weighted criterion was 0.3938 K-3 criteria, followed by K-4 0.2432, K-2 0.1933 and finally 0.1697 K-1 criteria. As a result of the analysis made between the sub-criteria depending on the main criteria, the value of the sub-criterion (A.K.) with the highest value, as a result of the analysis made depending on the K-1 main criterion, was A.K.-4 0.4105. As a result of the analysis made depending on the K-2 main criterion, the highest sub-criterion was A.K.-4 with 0.3259. As a result of the analysis made depending on the K-3 criterion, the sub-criterion with the highest value was A.K-3 with 0.2724. As a result of the analysis made depending on the K-4 main criterion, the sub-criterion with the highest weight was A.K.-4 with 0.3286. In the DEMATEL method, only the main criteria were included in the analysis and the following results were obtained. Considering the D+R values, the criterion with the highest value was the criterion K.-4 16,29372. In other words, the K.-4 criterion has a decisive effect on other criteria. When the D-R values were examined, the positive criteria with the highest values were K.-3 0.65064 and K.-4 0.08042 criteria. According to this result, other criteria with positive values affect other criteria. Sub-criteria with negative values are affected by criteria with positive values.

4. Conclusion and Recommendation

Occupational accidents are situations that occur unexpectedly and often have the potential to damage life and property. In the occurrence of an occupational accident, there is often the interaction of more than one element. At this point, machine, human and environment are the main factors that cause occupational accidents. For this reason, all kinds of activities (risk assessment, emergency plan, checklists, etc.) for occupational safety are prepared by taking these factors into account. Today, although advanced technologies (automation, signaling, etc.) are being used in the industrial industry, the desired level in occupational accident rates has not been reached.

In this study, the issues that cause the occurrence of occupational accidents are examined with AHP and DEMATEL methods within the scope of cause-effect relationship. The criteria and sub-criteria created in the study were prepared by taking the literature and expert opinions. As a result of the analysis using the AHP method, the consistency ratio was found to be 0.1 >0.0907. According to the analysis result, K-3 (other factors; human, physical factors, ergonomics, psycho-social factors, etc.) was the criterion with the highest weight. Technological developments in the industrial industry have also affected the way of doing business in production processes. Labor-based production has started to give way to machine-based production. If the necessary precautions are not taken, this situation will cause the employees to be adversely affected by different physical risk factors both in the machine and office environments. According to another result of the analysis, the criterion with the highest weight was K-4 (legal regulations). In our country, Occupational Health and Safety No. 6331 and many regulations were issued in 2012.With these laws and regulations, the sustainability of occupational health and safety in workplaces is aimed. However, when the SGK data is examined, almost every year, between 1000 and 1300 employees die as a

result of work accidents. In this respect, it is thought that legal regulations are insufficient to prevent occupational accidents. As a result of another analysis made using the DEMATE method, the criterion with the highest D+R value was K.-4 (legal regulations). According to the results of this analysis, the K.-4 criterion was interpreted as having a decisive effect on other criteria. When the D-R value is examined, while the positive criterion with the highest value is 0.65064, K.-3, the second highest positive value is the K.-4 criterion with 0.08042. According to this result, criteria with positive values are affected by criteria with negative values. Negative value criteria (K-1 production method, K-2 cost) are affected by positive value criteria. When the study was evaluated in general, it was determined that the results of the analysis made with the AHP and DEMATEL methods were largely similar. It is thought that the K-4 criterion, that is, legal regulations, is of great importance in terms of the sustainability of occupational safety in preventing occupational accidents and creating a culture of occupational safety. While weighting the criteria according to the level of importance with the AHP method, it is interpreted that the criterion with the highest value in the DEMATEL method affects the other criteria and is related. It is possible to come across many studies using AHP and DEMATEL methods in the literature. However, no study has been found that reveals work accidents and examines them within the scope of cause-effect relationship. For this reason, it is thought that the study will make an important contribution to the literature.

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