Çukurova Üniversitesi Mühendislik Fakültesi Dergisi, 37(4), ss. 1127-1142, Aralık 2022
Cukurova University Journal of the Faculty of Engineering, 37(4), pp. 1127-1142, December 2022

A Decision Model for Examining the Impact of Industry 4.0 on the Human Resources Departments of Iron-Steel Production Companies

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Geliş tarihi: 16.05.2022 Kabul tarihi: 27.12.2022

Atıf şekli/ How to cite: ÖZ, T., KUVVETLİ, Y., (2022). A Decision Model for Examining the Impact of Industry 4.0 on the Human Resources Departments of Iron-Steel Production Companies. Çukurova Üniversitesi, Mühendislik Fakültesi Dergisi, 37(4), 1127-1142.

Abstract

The main aim of this study is to present a decision model to determine how the human resources processes in the iron-steel industry will be affected by the transition to Industry 4.0. Accordingly, data were obtained through a survey and analysis was carried out with the chi-square test for the hypotheses. Then, the most critical problems in the transition process are weighted with Shannon's Entropy method and the most suitable solutions for the transition problems are listed with the TOPSIS method. While increasing labor costs and constantly changing technologies are emerging as the weightiest transition problems, supporting the employees with trainings to adapt to new technologies and gain the necessary skills has been evaluated as the most important solutions for the problems of transition to Industry 4.0. Thus, a roadmap for the transition process was presented to decision makers.

Keywords: Transition to industry 4.0, Human resources management, Iron and steel production, Entropy method; TOPSIS method.

Demir-Çelik Üretim Şirketlerinin İnsan Kaynakları Departmanlarına Endüstri 4.0'ın Etkisinin İncelenmesi için Bir Karar Modeli

Öz

Bu çalışmanın temel amacı, demir-çelik sektöründeki insan kaynakları süreçlerinin Endüstri 4.0'a geçişten nasıl etkileneceğinin belirlenmesi için bir karar modelinin ortaya konulmasıdır. Buna göre, bir anket çalışması ile veriler elde edilmiş ve hipotezler için ki-kare testi ile analiz gerçekleştirmiştir. Sonrasında, Shannon'ın Entropi yöntemi ile geçiş sürecindeki en kritik problemler ağırlıklandırılmış ve geçiş problemleri için en uygun çözümler TOPSIS yöntemi ile sıralanmıştır. En ağırlıklı geçiş sorunları olarak, artan işçilik maliyetleri ve sürekli değişen teknolojiler ortaya çıkarken, çalışanların yeni teknolojilere uyum sağlamaları ve gerekli becerileri kazanmaları için eğitimlerle desteklenmeleri Endüstri

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4.0'a geçiş sorunları için en önemli çözümler olarak değerlendirilmiştir. Böylece, karar vericilere geçiş süreci için bir yol haritası sunulmuştur.

Anahtar Kelimeler: Endüstri 4.0'a geçiş, İnsan kaynakları yönetimi, Demir çelik üretimi, Entropi yöntemi, TOPSIS yöntemi

1. INTRODUCTION

The development of factories, the switch over to coal and coke in the iron sector, and the superb integration of the steam engine all contributed to the beginning of the first industrial revolution. Economic growth in some countries has occurred with the adoption of these innovations [1].

The second industrial revolution covers the period between 1870 and 1914. In this period, great breakthrough inventions emerge in energy, materials, chemicals, and medicine. It is seen that the inventions in this period are different from the previous period. The Second Industrial Revolution has brought its much more limited achievements to the broader range of activities and products in the first industrial revolution. Due to the unprecedented penetration of new technologies into the lives of the middle and working classes, living conditions and purchasing power have increased quickly [2].

The second industrial revolution led to growth in some areas. The chemical industry rises; thereby, various engines and sizes and related industries using oil refining and containers have become increasingly important [3, 4].

With the start of the third industrial revolution, a new era has begun towards the end of the 20th century. A sustainable global economy for the twenty-first century was built on the infrastructure of the Third Industrial Revolution, which was resulted in the creation of huge number of new firms. The Third Industrial Revolution spans a wide range of technical fields, including digital power grids, fuel cells, nanotechnology, hydrogen and other renewable energy technologies, information technologies, embedded computing, and hundreds of other technical fields [5].

Since the start of the Industrial Revolution, technological advancements have significantly increased industrial efficiency. Industrial production began with the steam engine in the nineteenth century, moved to electrical power in the early twentieth century, and was mechanized in the 1970s. However, in the following years, industrial-technological developments have led technology to go much further, especially by revealing information technologies, mobile communication, and e-commerce [6].

Human resources management (HRM) is a management function that forms the business's basis to maximize employee performance by employers' strategic goals [7]. HRM primarily examines how people are managed within organizations, focused on policies and systems. The HRM departments and organizations' units are responsible for some activities such as recruitment, selection and placement, training and development, performance evaluation, incentive and rewarding, workforce planning, and career planning. For example, it is responsible for balancing internal practices with regulations from government laws. HRM was the result of the human relations movement of the early 20th century when researchers began to document by researching the strategic management of the workforce and ways to create business value. Available jobs such as payroll and social rights management were at the forefront when human resources emerged. HRM is now mergers and acquisitions, talent management, succession planning, industrial and business relationships, and diversity due to globalization, company consolidation, technological progress, and more research, and HRM has become a management organization that includes functions such as participation [7].

With the advancement of technology and the spread of the internet, some changes occur in

HRM functions. Although these changes are more effective in large organizations in the early stages, they have become a key determinant for successful management in organizations of all sizes over time. Existing standard processes will continue for jobs that require face-to-face communication, but some processes will have to be changed. These applications may be job applications, job interviews are done via the internet, automated systems make payrolls, open employee information the systems, holiday applications are made with self-service applications, performance evaluations are made in the electronic environment, and e-training programs are becoming widespread.

There is a cost gap between world-class and average organizations; world-class companies currently spend 25% less money than competitors of the same scale, according to one research from a consulting firm called Hackett Group. According to analysis, the best 25% of organizations in terms of efficiency and performance also utilized 16% fewer human resources employees. The capacity of these businesses to operate with lower expenses and fewer human resources staff is thought to be mostly due to more effective use of information technologies. Another finding from the study is that CEOs are the people who receive direct reports from HRM leaders in organizations that operate to international standards [8].

One of the most critical consequences of technology is that it allows non-HR employees to participate in some of the tasks traditionally concentrated in the HRM department. Developing e-HRM applications and self-service technologies for managers and employees to manage their benefits is one of the best examples. The general usage method in HRM technologies is the use of software-based services. Since these software costs are very high, they are generally used by large-scale companies. As the cost barriers decrease and familiarity with technology increases over time, HRM technologies will find a more extensive use by small and medium business consumers.

Human resources experts have a big task to understand and use HRM technology effectively. With the HRM technologies, costs and administrative burdens will continue to decrease. It may reshape the human resources profession over time, and the need for new types of human resources specialists may increase. In the technology-based future, restructuring, creativity, and new competence models are essential for human resources professionals to succeed. For this reason, human resources professionals should closely follow the developments in HRM technology and develop their competencies accordingly. A good understanding of the role technology plays in supporting human capital management can help determine both the HRM function and human resources professionals' success [8].

The HRM and Industry 4.0 relations have not been widely discussed in the literature. Therefore, in this study, human resources' transformation in the iron and steel industry against Industry 4.0 and new technologies has been examined. Accordingly, a questionnaire is prepared better to understand the relationship of Industry 4.0 with human resources. It consists of content such as the most common problems in transforming human resources with Industry 4.0, the participation of the participants in the judgments detailed in these problems, and the solution suggestion for the problems encountered in the transformation experienced with Industry 4.0. In the study, human resources professionals working in the iron and steel industry are asked to answer these study questions, and as a result, it is aimed to examine the relationship between Industry 4.0 and human resources in the iron and steel industry.

2. LITERATURE REVIEW

In the study of Cerika and Maksumic, the effects of Industry 4.0 technologies on human resources are discussed. It is suggested that these technologies affect the companies' human resources but produce contradictory results. As a result of new information required for operations, layoffs are thought to be intense. Many scholars agree that Industry 4.0 will benefit more than harm, but still agree that it can lead to several disadvantages. Although the unemployment effect, which is one of the adverse effects, is not accepted as valid for many academics, it is one of the issues to be investigated. That study is developed to ensure the best use of Industry 4.0 technologies and guide against future problems. According to the results obtained from this, it has been seen that the technologies developed in connection with Industry 4.0 have a positive efficiency development effect on human resources [9].

In the study of Ermolaeva, the analysis of the human resources factor, structural changes, and companies' attitudes are included according to the changing conditions. Based on analyzes and future changes made, suggestions for appropriate management strategies have been made for companies. The logistics sector has been discussed as an example of the Industry 4.0 transformation and its impact on the workforce [10].

The study by Pessl et al. found that the notion of Industry 4.0 has recently presented difficulties in several manufacturing companies' divisions, including purchasing, production, intralogistics, sales, and human resources. To design and implement Industry 4.0 initiatives, a methodical methodology is required. Companies have made varying amounts of advancement in terms of new technologies, procedures, and organizational features. The initial implementation outcomes for an Austrian company demonstrate that a bottom-up process, as opposed to a comprehensive management change, dominates the organizational changes in this field. These findings point to two main issues that need to be addressed [11]: People with different departments should ideally be included in the maturity assessment process, as the human resources area is extensive and affects the entire company. Secondly, defining target requirements and implementing the final action plan becomes difficult, especially if Industry 4.0 has not yet integrated the overall strategy.

The information includes a literature review that analyzes the effects of Industry 4.0 and cyber-physical systems on human labor and work for the organization and reveals current research results is given [12]. It indicates that Industry 4.0 will result in a significant drop in the employment of low-skilled jobs, but instead will lead to an increase in tasks related to high-skilled jobs, planning, control, and information technology. Besides, researchers emphasize the increasing importance of continuous learning, education, and training, so that the workforce can meet the competence and competence requirements that result from Industry 4.0 technologies [12]. In Hecklaua et al. (2016), new strategic approaches are needed for holistic human resources management in manufacturing companies to deal with the information and competence problems associated with new technologies and processes by including Industry 4.0 in our lives. Due to the increase in automation systems involved in production processes, the number of highly complex work areas will increase, resulting in a high level of employees' training needs. The challenge is that employees shift their focus from routine workplaces to more complex processes and adapt to work environments [13].

According to Benesova and Tupa [14], the production itself and the labor market and education system have been affected by the industrial revolutions that have changed over the years. As a result of these changes, some professions and jobs have disappeared. Due to digitization and robotic development, the next industrial revolution known as Industry 4.0 has been faced. Only qualified and highly trained employees will be able to control these technologies.

According to Mamoudou and Joshi, senior executives take advantage of the power of information technology (IT) tools introduced with Industry 4.0 to achieve their business goals. Using IT tools not only meets company goals but also optimizes business processes. Information Technologies play a critical role in strengthening and completing human and business resources. A brief overview of information technologies usage possibilities used in the Human Resources (HR) management system is presented [15]. In a study by Yusoff et al., human resources management departments using information and communication technologies have started to use a system called E-HRM, which has become an increasingly important phenomenon. E-HRM can be narrowly defined as the technical support of human resources in organizations using internet technology [16]. A smart human resources framework is proposed by Sivathanu et al. [17]. Furthermore, it has been determined that IoT, artificial intelligence and big data are the most important technologies by researching what technologies are needed for a successful transition in their study [17].

The concept of Industry 4.0 has become widespread recently, and small and medium-sized enterprises need to keep up with the process to adapt to these competitive conditions. A study analyzes the difficulties in the transition process of small and medium enterprises to Industry 4.0 and considers these results, and contributes to the determination of strategic steps by questionnaires, analytical hierarchy, and analytical network processes [18]. Transitions to Industry 4.0 significantly affect manufacturing companies' operations and decisions. Therefore, a new multi-criteria decision-making method, the Best-Worst method (BWM) in Indonesia's leather industry, and solution methods on addressing the challenges of successfully implementing Industry 4.0 are studied [19]. The study of Huang et al. analyzes Industry 4.0 technologies in Peruvian micro, small and medium enterprises. In that study, the analytical hierarchy process is applied to data from business managers of 49 companies in the manufacturing sector [20].

One key point about the transition to Industry 4.0 is to select the best strategy that should be chosen systematically and challenging to decide. Multi-criteria decision-making methodologies (AHP-VIKOR) have been used to determine the most effective course of action because this decision is a process that requires taking into account a variety of different factors [21].

Besides the technology-related studies about HR, the multi-criteria decision-making methods are applied to HR's different aspects. In one of these studies, the performance evaluation of seven active companies in the petrochemical industries is evaluated using the fuzzy analytical hierarchy process method [22]. To select the most appropriate executives, Kusumawardani and Agintiara proposed implementing the fuzzy AHP-TOPSIS method in the executive selection process in a leading telecommunications company in Indonesia [23].

This study's main contribution is to examine the spread of new technologies, especially the Industry 4.0 approach, specifically for the iron and steel industry human resources, and to present findings that will help decision-makers. Besides, the innovative aspects of this study are:

1. Determining how human resources practices in the sector may vary with Industry 4.0 applications,

2. Determining the importance of the problems that will arise in the transition to Industry 4.0 and adaptation processes with multi-criteria decision-making techniques,

3. Sorting the solution approaches to problems in the transition to Industry 4.0 and adaptation processes with multi-criteria decision-making techniques.

3. MATERIAL

This study's material includes the questionnaire conducted with the participation of a group of 48 HR professionals in the iron and steel industry. Employees are not asked for personally identifiable information to explicitly answer the questions, but some questions are asked to understand the relationship between demographic and Industry 4.0 and human resources that would only contribute to the study. This questionnaire is delivered to 200 HR professionals working in about iron and steel industry, and 48 people who answered the questionnaire are evaluated as valid. These values show that our participants are 24% of the employees reached in this field.

In Turkey's iron and steel industry, there are around 150 companies in operation around [24]. Accordingly, it is assumed that approximately 500 professionals work in the human resources department and participate in the survey application. Therefore, it is calculated that the error level of the sample obtained according to the appropriate population size at the level of 95% safety is 13%. Some of the questions of the questionnaire study are prepared by making use of the previous studies. The questions and their references are given in Appendix 1.

4. METHODOLOGY

The outline of the proposed methodology is given in Figure 1. Accordingly, the survey study is applied to the firms first. The main survey results are then evaluated, and the hypothesis analysis is applied to the defined hypothesis. Furthermore, the main conclusion of this study is obtained from the multi-criteria decision-making approach. The criteria are weighted by Shannon's Entropy method and ranked by the TOPSIS approach. Both Shannon's Entropy and TOPSIS methods can be used with alternative-criteria matrix instead of pairwise comparisons; therefore, these methods are selected in this study.

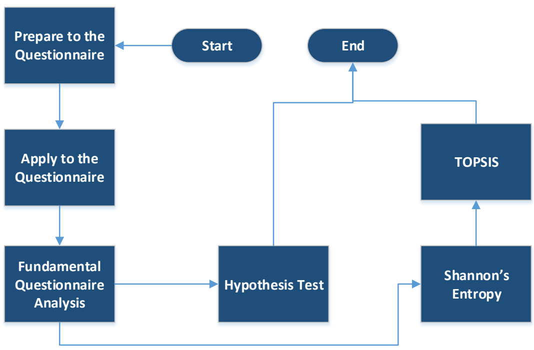

Figure 1. Outline of the methodology

Shannon's entropy is a multi-criteria decision-making technique that provides determining the weights. Using this method, the questionnaire values that can vary from 1 to 5 are used for the analysis. The steps of the algorithm are given as follows [25]:

1. Creating the decision matrix (X)

The rows of the decision matrix contain criteria, and the columns contain evaluation criteria to be used in decision making and can be defined as the starting matrix of the method. In matrix X given the Equation 1., m gives the number of decision-makers, n the number of evaluation criteria.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

2. Creating the normalized decision matrix (P)

The X matrix is normalized in order to make values between 0-1. The normalized decision matrix elements (p_{ij}) is calculated using the Equation 2.

$$p_{ij} = \frac{p_{ij}}{\sum_{j=1}^{m} p_{ij}} \quad (2)$$

Overall P matrix is defined by Equation 3.

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{m1} & \cdots & p_{mn} \end{bmatrix} \quad (3)$$

3. Calculating the entropy

The entropy levels (e_i) of each criterion is determined using Equation 4.

$$e_i = -e_0 \sum_{j=1}^{m} p_{ij} * \ln p_{ij} \quad (4)$$

where $e_0 = (\ln(m))^{-1}$

4. Calculating the degree of diversification

The degree of diversification (d_i) is calculated by subtracting e_i from 1 as given in Equation 5.

$$d_i = 1 - e_i \quad (5)$$

5. Calculating the weights of criteria

In this final step, the weights are computed by Equation 6.

$$w_i = \frac{d_i}{\sum_{i=1}^{n} d_i} \quad (6)$$

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the most popular multi-criteria decision-making methods, which assumes each criterion has a uniformly increasing or decreasing utility trend. Therefore, positive and negative ideal solutions are easily defined. The TOPSIS method evaluates the following decision matrix, which covers the m alternative evaluated for n criteria. The TOPSIS method is implemented in 6 steps as follows [26]:

1. Calculating the weights of criteria

The rows of the decision matrix contain alternative decision options based on the level of importance, and the columns contain evaluation criteria to be used in decision making and can be defined as the starting matrix of the method. In matrix *A* given the Equation 7., *m* gives the number of decision points, *n* the number of evaluation criteria.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{7}$$

2. Creating the normalized decision matrix (*R*)

All values are converted to normalized values between 0-1. In preparing the Normalized Decision Matrix, the first process is obtained by calculating the relative values of each criterion via the Decision Matrix data and then dividing the values by the relative value. The relative value (r_{ij}) is calculated using the formula (Equation 8).

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \tag{8}$$

Overall R matrix is defined by Equation 9.

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \tag{9}$$

3. Creating the weighted normalized decision matrix (V)

The weight values (w_i) related to the evaluation criteria are obtained from Shannon's Entropy method. (which provides to $\sum_{i=1}^{n} w_{i=1}$). Then the matrix in each column of the R matrix is created by multiplying the corresponding w_i to create the V matrix. The V matrix is created by Equation 10.

$$V = \begin{bmatrix} w_1 r_{11} & \cdots & w_n r_{1n} \\ \vdots & \ddots & \vdots \\ w_1 r_{m1} & \cdots & w_n r_{mn} \end{bmatrix} \tag{10}$$

4. Creating the positive (A^+) and negative (A^-) ideal solutions

The TOPSIS method assumes that each evaluation criterion consists of values ranging between minimum and maximum. To create the ideal solution matrix, the largest and the smallest of the weighted evaluation criteria in the V matrix are determined. Finding the positive and negative ideal solution matrix is shown in the formula (Equation 11) and (Equation 12), respectively.

$$A^+ = \left\{ (\max_i v_{ij} \mid j \in J), (min_i\, v_{ij} \mid j \in J') \right\} \tag{11}$$

$$A^- = \left\{ (\min_i v_{ij} \mid j \in J), (max_i\, v_{ij} \mid j \in J') \right\} \tag{12}$$

5. Calculation of distances to the positive and negative ideal solution

In the TOPSIS method, Euclidian Distance is used to find deviations from the ideal positive and negative ideal solution set of each alternative's evaluation criteria values. The deviation values for the alternatives obtained from here are called distance to positive ideal solution (S_i^+) and distance to negative ideal solution (S_i^-) and calculated by Equations 13 and 14.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \tag{13}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{14}$$

6. Calculation of the relative distance to the ideal solutions

In calculating the relative proximity of each decision point to the ideal solution or, in other words, the convergence value (C_i^+), positive and negative ideal distance measurements are used (Equation 15).

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \quad (15)$$

Where $0 \leq C_i^+ \leq 1$ and $C_i^+=1$ means that the alternative i is absolute proximity to the positive ideal solution while $C_i^+=0$ means that the alternative i is absolute proximity to the negative ideal solution.

5. RESULTS AND DISCUSSION

5.1. Questionnaire Results

According to the reliability analysis results, the Cronbach alpha value of the survey equals 0.901. It reveals that in the questionnaire's reliability analysis, the Cronbach alpha value above 0.900 means that the study is quite reliable. The expert profiles shown in Figure 2 includes %75 of the participants are specialist and above on the organization chart, which means that the opinions are obtained from the current strategy designers. According to the participants' education levels, % 89 of the participants have at least a BSc level education degree, which shows us that the opinions' profile is well educated.

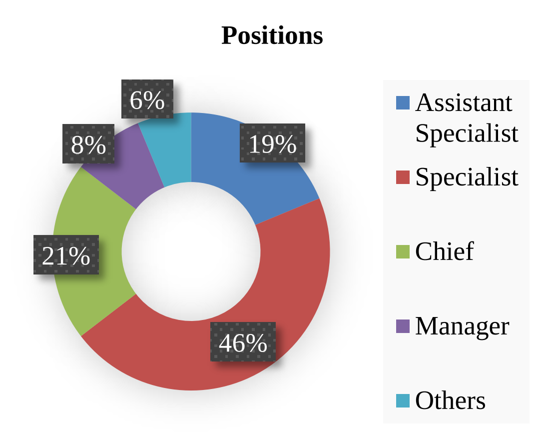

Figure 2. The profiles of expert levels

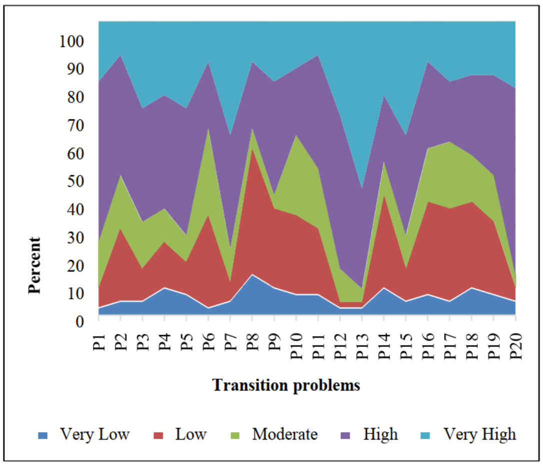

Figure 3. Expert opinions on the transition problems

The problems are faced on the transition to Industry 4.0 by HR's view as depicted in Figure 3. The most crucial problem seems to P13, P7, and P20. P13 is "the workforce planning for new jobs cause time and cost loss" while P7 is "personnel turnover rates are increasing." Finally, P20 is "uncertainties are experienced in the organizational charts." The organizational chart and workforce planning issues seem to be the most critical aspects in the transition to Industry 4.0.

The solution suggestions regarding these problems are given in Figure 4. The most important solutions are S1, S2, and S3, which are found to be %80 or above on the usefulness. The solution to the problems are given as follows in summary;

1. Focusing on gaining the necessary skills that employees need,
2. Supporting employees with training to adapt to new technologies,
3. Planning workforce on new jobs that will emerge with new technologies and the change of existing jobs,

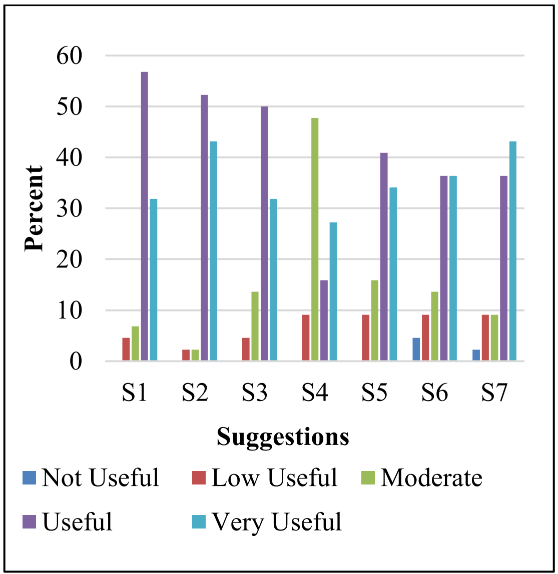

Figure 4. Expert opinions on the solutions of the problems

The hypotheses are defined as the importance of Industry 4.0 on the HR processes with the effectiveness of suggested solutions. The results are given in Table 1; the hypothesis test results of the relations between the participants' problems about the transition to Industry 4.0 in HR processes and suggestions for solutions to these problems can be seen. According to these results, the hypotheses (marked in bold) which significance values below 0.05 have statistically significant differences. Accordingly, the evaluations made according to the options with meaningful findings are summarized below:

1. According to P1 and S1, as a result of the emergence of new business lines with Industry 4.0, employees should be provided with the necessary skills they need.
2. According to P1 and S2, companies should support employees with training to adapt to new technologies due to the emergence of new business lines with Industry 4.0.
3. According to P1 and S3, due to the emergence of new business lines with Industry 4.0, companies try to take measures against change by workforce planning.
4. According to P1 and S5, companies should apply different performance evaluation criteria and receive regular feedback due to the emergence of new business lines with Industry 4.0.
5. According to P1 and S6, companies prepare their employees for future situations by planning their careers due to the emergence of new business lines with Industry 4.0.
6. According to P1 and S7, companies try to provide the fairest hierarchical structure in their organizational charts due to the emergence of new business lines with Industry 4.0.
7. According to P9 and S1, employees should be provided with the necessary skills they need due to changes in job descriptions with Industry 4.0.
8. According to P2 and S2, as a result of the changes in personnel competencies with Industry 4.0, companies should support employees with training to adapt to new technologies.
9. According to P12 and S3, companies should try to take measures against change by planning the workforce since the existing employees continue their duties with different competencies.
10. According to P20 and S4, companies should apply wage increases in proportion to the employees' increasing competencies due to uncertainties in the organizational charts with Industry 4.0.
11. According to P19 and S5, making it difficult to make career planning, companies should apply different performance evaluation criteria and receive regular feedback due to the new technological systems emerging with Industry 4.0.
12. According to P4 and S6, companies should prepare their employees for future situations by making career planning with the difficulty of finding qualified personnel suitable for new fields with Industry 4.0.
13. According to P18 and S7, it is difficult to determine the needs for new positions in orientation programs with Industry 4.0, and companies should try to provide the fairest hierarchical structure in their organizational charts.

Table 1. Questionnaire results: significance values of hypothesis

P/S	S1	S2	S3	S4	S5	S6	S7
P1	**0,000**	**0,000**	**0,005**	0,133	**0,006**	**0,000**	**0,002**
P2	**0,016**	**0,000**	**0,007**	0,181	0,077	0,191	0,075
P3	0,100	**0,006**	0,141	0,325	0,252	0,461	**0,033**
P4	**0,039**	0,100	0,296	0,618	0,391	**0,000**	**0,002**
P5	0,067	**0,000**	0,165	0,059	**0,035**	0,055	**0,012**
P6	0,402	0,069	0,064	0,264	0,207	0,336	**0,030**
P7	**0,036**	**0,044**	0,084	0,242	0,204	0,650	0,448
P8	0,063	0,402	0,381	0,065	**0,004**	0,114	0,517
P9	**0,002**	**0,004**	**0,042**	**0,038**	**0,001**	**0,003**	**0,000**
P10	**0,003**	**0,000**	**0,008**	0,398	0,346	0,188	0,113
P11	0,464	0,393	0,090	**0,021**	**0,029**	**0,011**	**0,038**
P12	**0,006**	**0,001**	**0,000**	0,245	0,217	0,050	**0,000**
P13	**0,014**	**0,009**	**0,007**	0,260	**0,032**	**0,001**	**0,030**
P14	0,212	**0,010**	**0,017**	0,192	**0,044**	0,121	**0,021**
P15	0,292	0,630	0,064	0,213	0,300	0,167	0,222
P16	0,332	0,639	0,310	0,281	0,531	0,566	0,251
P17	0,155	**0,001**	0,057	**0,047**	**0,037**	**0,006**	0,096
P18	0,076	0,508	0,083	0,088	0,089	0,243	**0,001**
P19	0,521	0,150	**0,013**	0,073	**0,015**	**0,000**	**0,001**
P20	0,527	0,453	0,130	**0,000**	0,494	0,542	0,167
*Significant hypotheses are marked as bold							

5.2. Multi-Criteria Decision Making Results

Firstly, Shannon's Entropy technique is applied, and the weights of the transition problems are determined, and a consistency calculation is made. The application steps are given as follows:

i. Creating the decision matrix (X)

The decision matrix includes 48 rows (replies to the questionnaire) and 20 columns (problems of transition to Industry 4.0). Each of the matrix elements (x_{ij}) is defined between 1 and 5.

ii. Creating the normalized decision matrix (P)

The X matrix is normalized according to Equation 2, and the P matrix is created according to those values.

iii. Calculating the entropy

The entropy levels (e_i) of each criterion is determined using Equation 4 is given in Table 2.

Table 2. Entropy levels of the problems

Problems	e_i	Problems	e_i
P1	0.9920	P11	0.9833
P2	0.9848	P12	0.9937
P3	0.9874	P13	0.9941
P4	0.9819	P14	0.9767
P5	0.9857	P15	0.9873
P6	0.9846	P16	0.9806
P7	0.9892	P17	0.9814
P8	0.9723	P18	0.9783
P9	0.9790	P19	0.9817
P10	0.9813	P20	0.9915

iv. Calculating the degree of diversification

The degree of diversification (d_i) is calculated by Equation 5 is given in Table 3.

Table 3. Degrees of diversification of the problems

Problems	d_i	Problems	d_i
P1	0.0080	P11	0.0167
P2	0.0152	P12	0.0063
P3	0.0126	P13	0.0059
P4	0.0181	P14	0.0233
P5	0.0143	P15	0.0127
P6	0.0154	P16	0.0194
P7	0.0108	P17	0.0186
P8	0.0277	P18	0.0217
P9	0.0210	P19	0.0183
P10	0.0187	P20	0.0085

v. Calculating the weights of criteria

Table 4. Final weights of the problems

Problems	w_i	Problems	w_i
P1	0.0254	P11	0.0533
P2	0.0486	P12	0.0202
P3	0.0402	P13	0.0190
P4	0.0577	P14	0.0745
P5	0.0456	P15	0.0406
P6	0.0491	P16	0.0619
P7	0.0346	P17	0.0595
P8	0.0886	P18	0.0692
P9	0.0672	P19	0.0584
P10	0.0596	P20	0.0270

In this final step, the weights are computed by Equation 6. The weights are shown in Table 4. The most important criteria are P8- Labor costs increase, and P14- Continuously changing technologies will require companies to plan workforce.

Secondly, the solution usefulness of the transition to Industry 4.0 is evaluated by the TOPSIS approach. Accordingly, the results of the TOPSIS approach are given as follows:

vi. Creating the decision matrix (A)

The decision matrix includes 20 rows (problems of transition to Industry 4.0) and seven columns (problems of transition to Industry 4.0). The values obtained from the geometric mean of relative scores which is calculated by dividing replies. Then, the values are re-scaled between 1 and 9 according to these geometric means. The decision matrix is given in Table 5.

Table 5. Decision matrix of TOPSIS

	S1	S2	S3	S4	S5	S6	S7
P1	4	4	3	2	3	3	3
P2	6	6	5	4	5	4	5
P3	4	5	4	3	3	3	4
P4	5	6	5	3	4	4	4
P5	4	5	4	3	4	3	4
P6	6	7	6	4	5	5	6
P7	3	4	3	2	3	2	3
P8	8	9	8	6	8	7	8
P9	6	6	5	4	5	5	5
P10	6	7	6	4	6	5	6
P11	6	6	6	4	5	5	5
P12	3	3	3	2	2	2	3
P13	2	3	2	1	2	1	2
P14	6	7	6	4	6	5	6
P15	4	4	3	2	3	3	3
P16	6	7	6	5	6	5	6
P17	6	7	6	4	5	5	5
P18	6	7	6	5	6	5	6
P19	6	6	5	4	5	4	5
P20	3	4	3	2	3	2	3

vii. Creating the normalized decision matrix (R)

All values are converted to normalized values between 0-1 according to Equation 8.

viii. Creating the weighted normalized decision matrix (V)

The weighted normalized decision matrix is calculated by Eq. 10. V matrix is calculated by multiplying the weights given in Table 4 with the normalized decision matrix given in Table 6.

ix. Creating the positive (A^+) and negative (A^-) ideal solutions

In order to obtain the positive and negative ideal solutions, the maximum and minimum elements of the V matrix are selected as follows:

$A^{+} = \{0.0044, 0.0125, 0.0077, 0.013, 0.0087, 0.0136, 0.0053, 0.0337, 0.0181, 0.0170, 0.0143, 0.0028, 0.0022, 0.0212, 0.0070, 0.0191, 0.0160, 0.0214, 0.0150, 0.0041\}$

$A^{-} = \{0.0031, 0.0105, 0.0057, 0.0107, 0.0074, 0.0117, 0.0037, 0.0304, 0.0154, 0.0147, 0.0122, 0.0019, 0.0010, 0.0184, 0.0050, 0.0159, 0.0138, 0.0178, 0.0126, 0.0029\}$

x. Calculation of distances to the positive and negative ideal solution

The deviations from the ideal positive and negative ideal solution set of the problem values for each solution. The deviations from the positive (S_i^{+}) and negative (S_i^{-}) solutions are given in Table 7.

xi. Calculation of the relative distance to the ideal solutions

Table 6. Distance calculations of suggestions

	S_i^{+}	S_i^{-}	C_i^{+}
S1	0.0068	0.0056	**0.5486**
S2	0.0068	0.0056	**0.5486**
S3	0.0061	0.0056	**0.5200**
S4	0.0060	0.0066	0.4772
S5	0.0058	0.0063	0.4787
S6	0.0061	0.0063	0.4891
S7	0.0061	0.0056	**0.5211**

The relative distances from positive and negative solutions are calculated using Eq. 15. as given in Table 6. According to the results, the best solution is the S1, "S1 - Focusing on gaining the necessary skills that employees need," and S2, which is "supporting employees with training to adapt to new technologies." The rest of the crucial solutions are given as follows:

1. S3 - Planning workforce on new jobs that will emerge with new technologies and the change of existing jobs.
2. S7 - Revising the organizational charts according to the new positions.

Another finding to be obtained from the TOPSIS result is that the solutions' relative distance values are very close and that each solution is very effective on the specified problems.

5.3. Results

The study can be considered two-fold; determining the effects of the HR processes on the transition to Industry 4.0 and determining the best solution for these processes' problems. The importance of the problems is shown in Figure 5. Accordingly, the most affected problems are related to the training process of HR. It shows that the new technology era needs more and different training processes. It can be explained with the need of technology in the Industry 4.0. Since Industry 4.0 expresses a very complex and holistic technological development, it requires many different technologies such as artificial intelligence, cloud computing, big data, and this allows complex tasks such as planning and management to be done, even remotely [28]. The second most essential processes are workforce planning and wage management processes. It means that the new era forces firms to new workforce planning and wage management processes.

When the hypothesis test results are examined, it is seen that revision of the organizational charts according to the new positions as the S7 and supporting employees with training to adapt to new technologies as the S2 is the proposal that has a significant effect on the problems in the hypothesis tests. Similar organizational transformation and training requirements were identified as important for all SMEs in an evaluation study conducted with eleven different critical success factors [29].

According to the multi-criteria decision-making results, supporting employees with training to adapt to new technologies (S2) and focusing on gaining the necessary skills that employees need (S1) are evaluated as the essential solutions.

Generally, it is seen that S1, S2, and S7 are the most efficient solution to the HR problems related to the transition to Industry 4.0. The executives should provide changes on the organization charts for gaining the necessary skills and training for adopting the new technologies of employees.

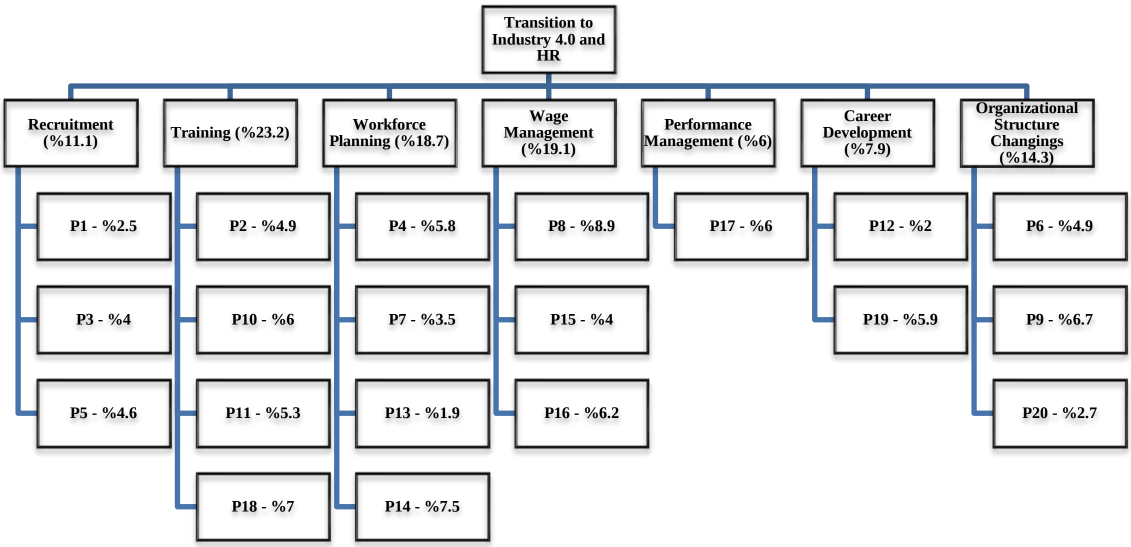

Figure 5. Importance of the HR problems on the transition to Industry 4.0

6. CONCLUSION

Since Industry 4.0 is a comprehensive concept, its effects on Human Resources are discussed in this study. Seeing the effects of Industry 4.0, especially on the Human Resources departments' employees, is our main research topic. Since Human Resources is an area in every sector, human resources employees, in particular, constitute the target audience. Since the iron and steel industry is an area that requires constant adaptation to new technologies, to be supported by research and development activities, and with varying dynamics, it is thought that the effects of Industry 4.0 will be seen more closely.

In the study, studies investigating the effects of Industry 4.0 on human resources were examined. Based on these studies, some problems caused by Industry 4.0 in human resources departments have been identified. Solutions to these problems are discussed. By preparing a survey study stating the problems and their solutions, human resources professionals working in the iron and steel industry are requested to reply to the questionnaire. As a result of this survey, 48 HR professionals are reached. With the increase in the number of attendants to obtain more meaningful data, more people can be reached by including human resources departments in different firms.

According to the calculations made with Shannon's Entropy and TOPSIS methods, the most common problems encountered in the transformation with Industry 4.0 is the change in the workplace definitions, the increase of labor force and cost losses, the difficulty of making workforce planning. The ideal solution that can be applied to these problems is to support employees with training to adapt to new technologies.

The approaches that may be used with fuzzy versions can also be examined. Besides, applying similar studies in different sectors or with other multi-criteria decision-making techniques may also constitute an idea for other studies.

7. ACKNOWLEDGEMENTS

This study is derived from Tuğba Öz's master's thesis, which is completed at Çukurova University, Department of Industrial Engineering.

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9. APPENDIX

Appendix 1- HR problems and solutions of the transition to Industry 4.0

Q	Description	References
P1	New business lines are emerging with Industry 4.0.	[10,12]
P2	Required staff competencies are changing.	[9]
P3	It is difficult to determine the competencies required by new business lines in recruitment.	[9]
P4	It is difficult to find qualified personnel suitable for new areas.	[9]
P5	Recruitment stages are long and multi-stage.	[10]
P6	New technological systems reduce the need for humans.	[9, 10, 12]
P7	Personnel turnover rates are increasing.	[13]
P8	Labor costs are increasing.	[10]
P9	It causes changes in job descriptions.	[12]
P10	Training needs are increasing.	[9, 10]
P11	With the increasing need for training, the labor force and cost losses increase.	[27]
P12	Continuation of the current employees is possible by gaining different competencies.	[10]
P13	Planning the workforce for new jobs causes time and cost loss.	[16]
P14	Continuously changing technologies will require companies to plan their workforce.	[10]
P15	It is difficult to determine the wage interval for new business lines.	[27]
P16	It causes an imbalance in wage scales.	[27]
P17	It is necessary to create different performance evaluation systems.	[10]

P18	It is difficult to determine the needs for new positions in orientation programs.	[10]
P19	New technological systems make it difficult to make career planning.	[13]
P20	Uncertainties are experienced in the organizational charts.	[10]
S1	I focus on gaining the necessary skills that employees need.	[9]
S2	I support my employees with training to adapt to new technologies.	[9,10]
S3	I plan workforce on new jobs that will emerge with new technologies and the change of existing jobs.	[16]
S4	I apply an increase in wages in proportion to the increased competencies.	[27]
S5	I apply different performance evaluation criteria in line with emerging technologies and receive regular feedback.	[10]
S6	I determine the requirements and future conditions of new business lines and make career plans accordingly.	[13]
S7	I revise my organization charts according to new positions, and I try to create the fairest hierarchical structure.	[10]