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Evaluation of the Difficulties in the Internet of Things (IoT) with Multi-Criteria Decision-Making

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Abstract: The rapid development of technology has increased the desire of all to be on the Internet. The discovery that objects born of the Internet communicate with each other without external factors revealed, with the fourth industrial revolution, the concept of the Internet of Things (IoT). The communication of objects with each other means minimum labor and minimum cost for enterprises. Enterprises that want to transition to the Internet of Things face many difficulties. Identifying and correcting these difficulties can lead to both lost time and high cost. In this study, we investigated the difficulties encountered in the Internet of Things. As a result of the study, the degree of importance of the factors causing these difficulties was determined by multi-criteria decision-making methods and was presented to the enterprises. The main criteria, and the sub-criteria related to these main criteria, were determined. The main purpose of the enterprises transitioning to Industry 4.0 is the communication of things with each other. In this study, we aimed to determine which criteria caused difficulties in the transition to Industry 4.0. Then, the degree of importance of the criteria was determined using the analytic hierarchy process (AHP) and analytic network process (ANP) methods, in the multi-criteria decision-making. Through the study, we determined which criteria should be taken into consideration by the enterprises that want to transition to the Internet of Things. In this way, enterprises will be able to accelerate that transition by minimizing time and monetary loss.

Keywords: Internet of Things; IoT; multi-criteria decision-making; analytic network process; analytic hierarchy process

1. Introduction

The Internet of Things (IoT) has long been in existence, although today it is part of the concept of the fourth industrial revolution, called Industry 4.0. The industrial revolution began with the invention of the modern charcoal-powered steam engine by James Watt and was followed by the use of electricity and oil in mass production [1]. In the following years, with the use of the Internet becoming widespread, the Internet of Things was reached.

The Internet of Things (IoT) is defined as a network between things that can be addressed in a unique way, because the things in that network communicate with a common protocol [2]. Although there is no standardized architecture in the Internet of Things, there are similar architectural structures in the literature. The Internet of Things is the transmission of information to another object or device with the analog or numerical data it receives from the environment. This continuous connection is possible by increasing the interoperability between physical devices. In the literature, Andročec et al. [3] conducted research on how this association was formed. This research also provided an overview of the studies on interoperability with the IoT. Lelli [4] introduced the principle of "smart interoperability" into the concept of Industry 4.0 and emphasized that this association could

be achieved with the Internet of Things. According to the IoT definition, we can define four layers pertaining to information about the environment, the device or object, the transmission, and the software and data. The purpose here is to determine what information the device or objects will define [2]. Enterprises will have the opportunity to control Industry 4.0 and the IoT applications in their production or service processes. These processes will be measurable and manageable in their own enterprises. Enterprises that are far from these innovations will not be able to survive in a competitive environment. The technological and digital transformations in the consumption and production processes require adaptation to Industry 4.0. As in every new process, there are some difficulties faced by enterprises in this transformation process. The current inadequacy of the infrastructure required for the transformation process is one of these difficulties. In addition, a lack of understanding of consumer behavior and a lack of available resources to meet requests are among these difficulties. Social problems such as the inadequacy of R and D studies, information pollution or lack of information, and the potential unemployment associated with robotic processes are some of the problems that enterprises will face. Industry 4.0 may be adversely affected by the enterprises without personnel trained for this digital transformation.

Kutup [5], Zhu [6], and Yiğitbaşı [7] examined the advanced functions of the Internet of Things. Bonomi et al. [8], Erdem [9], and Gökrem and Bozuklu [10] developed a platform for the Internet services and applications of objects in critical areas such as smart cities, smart grids, wireless sensors, and actuators. Doğan and Arslantekin [11], and Aktaş et al. [12] studied the technological development of objects and gathered data about technological advances in different fields. These data were analyzed in the areas in which they were obtained.

With the rapid progress of today's technology, the need for the Internet is increasing day by day. The Internet of Things, which emerged with the concept of Industry 4.0, plays an important role for enterprises due to today's technology. Therefore, every company that wants to remain in the market must transition to the Internet of Things. In that process of transition, the problems encountered by the enterprises are costly and time consuming. In this study, the difficulties encountered in the Internet of Things were examined. The criteria were determined with the help of expert opinions and a study by Mohammadzadeh [1]. The main criteria and sub-criteria were taken into consideration. The analytic hierarchy process (AHP) and analytic network process (ANP) methods were used to determine the weights of the criteria. The main criteria determined are communication, technology, business, privacy and security, legal regulations, and culture. The determined sub-criteria address data management, infrastructure, software, architecture and design, device heterogeneity, hardware structure, fault tolerance, data confidentiality, network security, Internet of devices, security of devices, software security, conflict of interest, business model, investing in the development of the Internet of Things, economic development opportunities and problems, customer expectations and service quality, data utilization rate, belonging, standardization, liability, education and ethics of education, ethics, trust, and vandalism. The integration of Industry 4.0 applications into manufacturing sector enterprises is an opportunity to expand the customer base. In particular, applications developed in production shorten the production process and reduce the complexity of operations. They also increase the internal communication and interaction within the enterprise. Fera et al. [13] reviewed new perspectives in production processes and previously conducted research in order to determine the problems encountered in the processes. Thus, Industry 4.0 applications that are presented in that study and provide information exchange interfere with the enterprises. There may also be difficulties in the transition of Industry 4.0 applications to enterprises. The analysis of the factors causing these difficulties enables an easier control of the transition process for the enterprises. It also facilitates that transition. In such cases, various solutions can be used to analyze the criteria in the literature. Multi-criteria decision-making methods are also effective tools for this kind of analysis [14]. In this study, the advantages of the AHP and ANP methods, which are multi-criteria decision-making methods, were applied.

First, the degree of importance was listed of criteria affecting the difficulties encountered in the Internet of Things with the AHP method. Then, the related criteria and their degree of importance were determined by the ANP method. The reason for choosing a medium-sized business as the application area is that the effects of Industry 4.0 applications on the enterprise can be more easily controlled than with large-scale enterprises. At the same time, such innovations can be more easily adapted to the enterprise. The difficulties encountered in this transition process are easy to identify according to smaller enterprises. For these reasons, the application area of the study is a medium-sized enterprise. The transition of this enterprise to Industry 4.0 and the Internet of Things can expand the customer base addressed.

Recently, the Internet of Things, which is on our agenda with the concept of Industry 4.0, has occupied an important place with the rapid progress of technology and the transfer of all the options in our lives to the Internet. For companies, the Internet of Things is a very complex concept and it is difficult to determine what the difficulties are and how the companies can prevent them. Because of this, the criteria affecting the Internet of Things are discussed in this study.

The analytic hierarchy process (AHP) method was used in order to evaluate the criteria discussed by the experts in the enterprises and to find the degree of importance. Interactions between the criteria were determined and the analytic network process (ANP) method was used for the degree of importance of the criteria according to these interactions.

The study consists of six sections. The concept of Internet of Things and the criteria of the problem are briefly mentioned in the first section. In the second section, general information about the Internet of Things is mentioned. In the third section, multi-criteria decision-making problems are presented while discussing AHP and ANP methods. In the fourth section, studies on the Internet of Things are examined. In the fifth section, the degree of importance of the affected criteria in the Internet of Things is discussed. In the sixth section, the results of the study are given and suggestions are made for future studies.

2. Internet of Things

The concept of the Internet of Things has many different definitions in the technological dimension. This is because researchers and enterprises allocate importance to the Internet of Things depending on their infrastructure and interests. In general, the concept of the Internet of Things is based on three approaches: the Internet-based approach, the meaning-based approach, and the object-based approach. Intelligent objects are entering our lives with the concept of the Internet of Things, such as applications that can communicate on the network, have a single address, are based on standard communication protocols, and can detect changes such as heat, light, and radiation. Structures that can hold the data obtained as a result of the application and transfer this data to the responsible people are called Internet of Things Technologies [2].

In the literature, Köroğlu [2], Jia [15], and Hassanalieragh [16] provided information on opportunities and difficulties in the Internet of Things and highlighted various issues such as analysis and cost reduction. Al-Mabrouk and Soar [17], Syamsuddin and Hwang [18], Toğrul [19], and Azad and Dehbasteh [20] benefited from the advantages of using various methods on the Internet of Things, continuing their research on its use.

Observing the deficiencies in the development of Internet of Things systems is an important point for the progress of studies in this field (Bulut and Taner [21], Söğüt and Erdem [22]). They made recommendations to be taken into consideration in studies on the Internet of Things.

Mohammadzadeh [1], Tyagi and Sharma [23], Turak and Beceni [24], Sevinç et al. [25], and Uslu et al. [26] observed the shortcomings in the development of Internet of Things systems and highlighted important points for technology/information security and suggested strategies for them.

The Internet of Things is the environment created by smart devices that communicate with each other in a variety of ways, generating information in these communications and exchanging information in the network they form among themselves. The Internet of Things system,

when combined with objects, sensors, and electronic circuits, help systems begin to acquire the characteristics of thinking, feeling, and speaking. In this way, they communicate with the environment and keep current status information [5].

3. Materials and Methods

With technology rapidly developing in recent years, interest in the Internet of Things has been increasing day by day. Enterprises operating in the fields of production and service face many difficulties while transitioning to the Internet of Things. The process of identifying these difficulties and taking measures against them is very slow. Therefore, this study identifies the difficulties faced in the transition process to the Internet of Things by medium-sized enterprises operating in Turkey. In the study, the AHP and ANP methods were used. Factors leading to the difficulties encountered during the transition to Industry 4.0 were identified. These factors were evaluated using the AHP and ANP methods. Factors in the AHP method were modeled hierarchically. Then, the relationships and interactions between these criteria were checked. It is determined how the criteria are influenced in relation to and interaction with the ANP method. A network structure was established among the criteria. Binary comparison matrices were formed in both methods and consistency analyses were performed. The significance levels of these criteria were then calculated.

Multi-criteria decision-making methods are used in many areas. It is known that people find different solutions to solve the problems they face in their lives. Considering these pathways, there are methods that evaluate all criteria that affect this problem. These methods are referred to as multi-criteria decision-making methods in the literature and there are important studies in this area.

3.1. Analytic Hierarchy Process (AHP)

It is known that people apply different methods to solve the problems they face in daily life. When these paths are taken into consideration, multi-criteria decision-making methods are defined as methods that evaluate the criteria affecting these problems. Many studies have been conducted in the literature with multi-criteria decision-making methods [27]. In this study, the analytic hierarchy process (AHP) method was used.

AHP is the method where ideas are shared among the identified groups to make solutions among themselves and these ideas are digitized according to a scale determined by Saaty.

The problem in AHP is shaped in a hierarchical tree structure. After the creation of the hierarchy, the degree of importance of the criteria against each other is calculated. The decision-makers for this calculation decide the degree of importance between the criteria based on the 1–9 scale generated by Saaty. The decision-making process by the analytic hierarchy method consists of the following stages [28]:

Step 1: Criteria and alternatives are determined by defining the problem. Hierarchical tree structure is created according to these criteria and alternatives.

Step 2: After the hierarchy has been created, a pair of 1–9 based on the expert opinion is used. This ensures that the decision-maker has separate jurisdiction over all criteria.

Step 3: The generated binary comparison matrix is normalized. Column totals are taken for this, and each value is divided by its column sum. Thus, a normalized matrix is obtained.

Step 4: Once the normalized operation is performed, the priority (weight) vectors for the criterion in the hierarchy are calculated.

Step 5: Once weights are obtained, the decision-maker measures whether the items in the hierarchy are bilaterally consistent. Consistency index (CI), which is considered as an indicator of proximity to consistency, is calculated.

Step 6: After calculating the CI value, a consistency ratio (CR) is obtained which is the ratio of CI to the rationality index (RI). In AHP applications, the CR that is less than 0.1 indicates that the application is consistent [10].

Özcan et al. [29] have used the AHP method and goal programming for a large-scale hydroelectric power plant in Turkey. Taş et al. [30] selected the most suitable line type among alternative line type options by using AHP and The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) in a monorail transportation line. Gür and Eren [31] used the AHP and TOPSIS methods for the selection of third-party logistics (3PL) firms in an online shopping site. In Taş et al. [32], the AHP and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods were applied to the health sector.

3.2. Analytic Network Process (ANP)

Sometimes the factors affecting decision-making may not be structured hierarchically because of their interdependencies and their commitment among themselves. Analyzing such decision-making problems requires consideration of the interactions between clusters. Saaty [14] proposed the ANP method for use in problems with such internal or external dependencies between alternatives and criteria [33].

The ANP method consists of five steps:

Step 1: Defining the problem and creating the network structure.
Step 2: Creating the binary comparison matrices.
Step 3: Calculating the consistency of matrix vectors and consistency analysis.
Step 4: Creating the super matrix.
Step 5: Selecting the best alternative and criterion [33].

With respect to the ANP method, Gür et al. [34] used it in education, Özcan et al. [35] and Özcan et al. [36] used it in energy, and Akca et al. [37] and Gür et al. [38] used it in health.

4. Case Study

In this study, technology development difficulties related to the Internet of Things in medium-sized enterprises in Turkey were evaluated. The study's aim was to determine the difficulties of developing Internet of Things technology by studying the order of importance of criteria. The criteria that should receive particular attention were emphasized. Criteria were determined based on the study of Mohammadzadeh [1] and the company that corresponded to the application area. The application area was a medium-sized enterprise, and such an enterprise that was undergoing a transition to the Internet of Things technology was selected for discussion. In order to evaluate the criteria in the study, experts were consulted for their opinions. In accordance with the resources of the company, three experts were consulted. These experts were people who did research on the Internet of Things and Industry 4.0. The experts also knew about the study of Industry 4.0 and the Internet of Things in the literature.

The small number of experts is among the limitations of the study. In order to prevent this leading to insufficient evaluations, the literature was also used to verify the accuracy of the evaluations made in the study. The AHP and ANP methods were then used in the evaluation of the three experts' opinions in the field of the Internet of Things. Binary comparison matrices were evaluated separately by the experts. Each expert transferred their views to the binary comparison matrices. These evaluations were then combined with the geometric mean. These final binary comparison matrices were also used in the AHP and ANP methods. The flowchart of the problem is shown in Figure 1. The work was carried out in line with the directions in the flowchart.

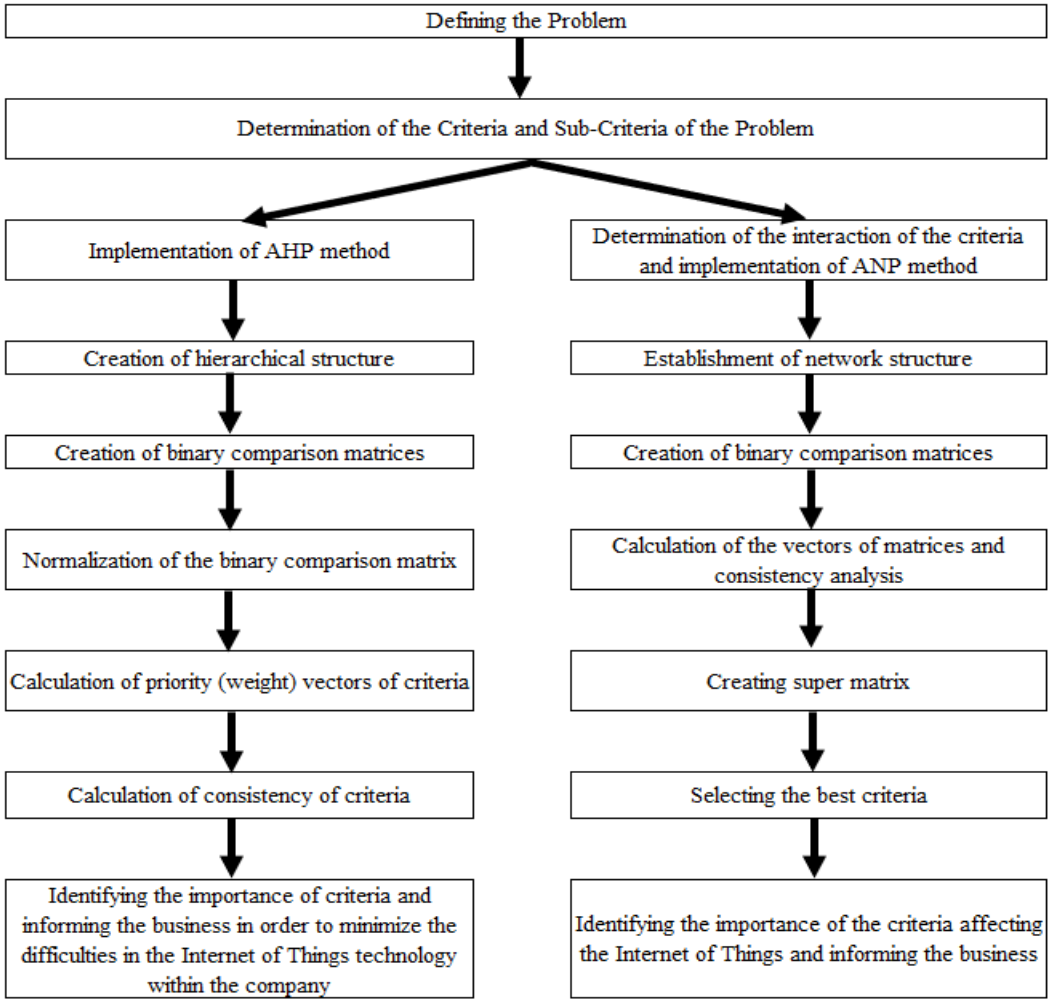

Figure 1. Flowchart of the problem.

Studies on the Internet of Things in the literature review were examined. In the literature, research involving the same problem addressed in this study was investigated. At the same time, the criteria and evaluations were determined in parallel with the literature. In order for the results of the study to contribute to studies in the literature, investigations were conducted. In the literature, it is observed that every branch of science is important and still developing. Although the concept of the Internet of Things is relatively old, it has remained dynamic because of the rapidly developing technology. The study was conducted with a medium-sized enterprise. The criteria for the Internet of Things were examined and evaluated by three IT experts at the enterprise where the study was conducted and then the AHP method and ANP method were introduced. There were six main criteria and 26 sub-criteria determined by the experts for the company. The experts carrying out the evaluation first examined the structure of the enterprise. The experts then examined the concepts of Industry 4.0 and Internet of Things in the literature. Based on the Mohammadzadeh [1] study, the effective criteria for this problem were determined. The applicability of these criteria to the enterprise was discussed by experts and the evaluation process was carried out. The main criteria and sub-criteria are shown in Tables 1 and 2. Table 1 defines the criteria and abbreviations shown in the solution process. Table 2 provides an explanation of the criteria discussed.

Table 1. Main criteria and sub-criteria.

Main Criteria	Sub-Criteria	Abbreviation
Communication (COM)	Addressing	A
	Data Management	DM
	Infrastructure	I
	Software	SW
Technology (TECH)	Architecture and Design	AD
	Heterogeneity of Devices	HD
	Hardware Structure	HS
	Fault Tolerance	FT
Privacy and Security (PandS)	Data Privacy	DP
	Network Security	NS
	Internet of Things Device Security	ITDS
	Software Security	SS
	Conflict of Interest	CI
Job (J)	Business Model	BM
	Investing in Internet Development of Objects	IIDO
	Economic Development Opportunities and Problems	EDOP
	Customer Expectations and Service Quality	CESQ
Legal Regulations (LR)	Data Usage Rate	DU
	Ownership	O
	Standardization	S
	Global Cooperation of the Company	GCC
	Obligation	OB
Culture (CUL)	Ethics of Education and Teaching	EET
	Ethics	E
	Confidence	C
	Vandalism	V

Table 2. Sub-criteria description.

Sub-Criteria	Description
A	Compatibility of devices to IPV6 protocol.
DM	Keeping data in the cloud or data center.
I	The ability of the devices used to communicate with other relevant devices, the establishment of a substructure within the company, etc.
SW	The devices used for network communication (program language) and options.
AD	Design of the devices used and internal usability.
HD	The device used is communicating with multiple devices.
HS	Network cards of devices, routers (switches) and switches used for devices, frequency differences between devices, all hardware structure of the device.
FT	The rate of tolerance of the percentage (%) error shown to the device in the event of accessibility and availability of the device being used.
DP	Reliable database.
NS	The network used on the devices is resistant to external attacks, ensuring the security of every object's Internet protocol (authentication and encryption).
ITDS	The fact that the data held on the device is open to attack, that is, the firewall, the device/devices it is communicating with, and the inaccessibility other than authorized persons, the firewall it creates against external attacks.
SS	Confidentiality of the software language used in the testing phase, the reliability and validation of the software test applied.

Table 2. *Cont.*

Sub-Criteria	Description
CI	Civil rights conflict between legal issues related to Internet of Things devices. Data storage and disposal policies and the necessary legal liability for unintended use, security breaches or privacy periods are included.
BM	It is the compatibility of the devices used in the work area used.
IIDO	It is the measure of how the company should grow by investing in the development of the Internet of Things and how much investment it should make for this growth.
EDOP	Where medium-sized Internet of Things is located in economic development opportunities for medium-sized companies, addresses issues that may arise when it stops progress in this area.
CESQ	The customer expectations of devices created with Internet of Things technology and evaluation of the quality of service shown.
DU	The devices must have a certain amount of bandwidth and thus a data transfer rate in order to avoid data traffic. For this purpose, data usage rates should be determined in order to minimize the problems that may occur during the communication of the devices.
O	Realization of legal transactions in cases where the data of the devices used are owned by the company or produced or shared by third parties.
S	Protocols and encodings of connected systems can speak the same language, obstacles established to prevent the exchange of information outside the system, frequencies used on a device basis.
GCC	The company's compliance with the United Nations Global Compact and its participation in the 17 global development goals play an important role for companies.
OB	If the devices are subject to unknown security openings and damage to them or other devices, the laws are related to the relevant obligations that sufficiently address the legal charges.
EET	Providing training on the Internet of Things to all personnel working in the company.
E	The use of devices related to the Internet of Things is not affected in any way.
C	Providing internal and external trust for the devices used.
V	Personal information about the employee is not recorded.

4.1. Solution Stage with AHP

The determination of the criteria weights was achieved using the AHP method. In order to make it easier to compare the criteria in the study, the sub-criteria and explanations are given in Tables 1 and 2.

Creating a hierarchical structure

In order to solve the problem using the AHP method, the hierarchical structure of the problem should first be determined. The hierarchical tree structure created for the problem is shown in Figure 2.

Establishing a binary comparison matrix of the main criteria and sub-criteria

At the stage of establishing a binary comparison matrix of the criteria and sub-criteria, the IT experts in the enterprise were consulted for their opinions. The scale of Saaty's 1–9 was used [39]. Decision-makers answer the question of which of the two criteria is more important by making binary comparisons [39]. In order to evaluate a complex structure, experts are consulted. The geometric averages of expert opinions are taken. Expert opinions increase the accuracy of the decision to be taken. Experts are able to evaluate the problem according to their areas of expertise. The process of comparing the criteria made by each expert individually is combined to enable a common structure. For this, the geometric mean is frequently used in the literature [40].

A binary comparison matrix based on the five main criteria is shown in Table 3. Binary comparisons were made for the sub-criteria, such as the main criteria in Table 3. In order to be an example for other comparison matrices, the binary comparison matrix is shown for the study.

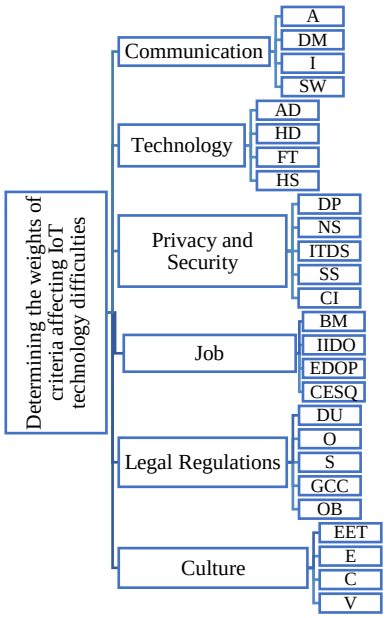

Figure 2. Hierarchical structure.

Table 3. Binary comparison matrix for main criteria.

Main Criteria	COM	TECH	PandS	J	LR	CUL
COM	1.00	0.50	2.00	3.00	4.00	5.00
TECH	2.00	1.00	3.00	4.00	5.00	6.00
PandS	0.50	0.33	1.00	2.00	3.00	4.00
J	0.33	0.25	0.50	1.00	3.00	4.00
LR	0.25	0.20	0.33	0.33	1.00	2.00
CUL	0.20	0.17	0.25	0.25	0.50	1.00

Calculation of normalization and relative importance weights

The square root of the sum of the squares of the values is taken in the binary comparison matrix in Table 3. The normalized matrix presented in Table 4 was then formed. The normalization process of the binary comparison matrix between the main criteria is given in Table 4 in order to show the calculation steps in the solution process of the AHP method. Similar processes are observed in other comparison matrices.

Table 4. Normalized matrix for main criteria.

Main Criteria	COM	TECH	PandS	J	LR	CUL
COM	0.23	0.20	0.28	0.28	0.24	0.23
TECH	0.47	0.41	0.42	0.38	0.30	0.27
PandS	0.12	0.14	0.14	0.19	0.18	0.18
J	0.08	0.10	0.07	0.09	0.18	0.18
LR	0.06	0.08	0.05	0.03	0.06	0.09
CUL	0.05	0.07	0.04	0.02	0.03	0.05

The consistency of the main criteria and sub-criteria were calculated using the AHP method and consistent results were obtained. The weights obtained using the AHP method are shown in Table 5.

Table 5. Criteria weights obtained by the analytic hierarchy process (AHP) method.

Main Criteria	Weights	Sub-Criteria	Weights	Result	Abbreviation
Communication (COM)	0.16	Addressing	0.45	0.070	A
		Data Management	0.32	0.050	DM
		Infrastructure	0.08	0.013	I
		Software	0.16	0.025	SW
Technology (TECH)	0.38	Architecture and Design	0.47	0.175	AD
		Heterogeneity of Devices	0.28	0.104	HD
		Hardware Structure	0.10	0.036	HS
		Fault Tolerance	0.16	0.060	FT
Privacy and Security (PandS)	0.25	Data Privacy	0.26	0.064	DP
		Network Security	0.41	0.101	NS
		Internet of Things Device Security	0.16	0.039	ITDS
		Software Security	0.11	0.027	SS
		Conflict of Interest	0.06	0.014	CI
Job (J)	0.12	Business Model	0.47	0.055	BM
		Investing in Internet Development of Objects	0.14	0.016	IIDO
		Economic Development Opportunities and Problems	0.08	0.009	EDOP
		Customer Expectations and Service Quality	0.31	0.037	CESQ
Legal Regulations (LR)	0.06	Data Usage Rate	0.43	0.026	DU
		Ownership	0.16	0.010	O
		Standardization	0.26	0.016	S
		Global Cooperation of the Company	0.06	0.004	GCC
		Obligation	0.10	0.006	OB
Culture (CUL)	0.04	Ethics of Education and Teaching	0.09	0.004	EET
		Ethics	0.33	0.014	E
		Confidence	0.42	0.017	C
		Vandalism	0.16	0.007	V
TOTAL	1.00		TOTAL	1.000	

According to Table 5, the top three main criteria are technology with 38%, privacy and security with 25%, and communication criteria with 16%. In general, the top three sub-criteria are architecture and design at 17.5%, followed by heterogeneity of devices at 10.4% and network security at 10.1%.

The weights obtained as a result of AHP were evaluated by experts. When the results were analyzed, it was seen that the technology criterion comes first; it attaches importance to the privacy policy of the customers and the company. The rapid advancement of today's technology and the increasing need for protection against attacks on the confidentiality of personal/business information emphasize the fact that the results match the actual experiences of the enterprise. An enterprise that is applying the process should follow methods that take into account these results which reflect the difficulties encountered in regard to the Internet of Things.

In this study, the degree of importance of the difficulties related to the Internet of Things encountered by a medium-sized enterprise located in Turkey is listed. As a result of the AHP, it is seen that the technology criterion is of the highest priority and medium-sized enterprises should pay attention to it in order to avoid the difficulties encountered in applying the Internet of Things.

4.2. Solution Stage with ANP

In this study, the criteria affecting the Internet of Things and the importance of these criteria were taken into consideration. The degree of importance of the criteria was determined using the AHP method. However, the interaction between the sub-criteria was also determined. Considering this interaction, the degree of importance of the criteria was re-evaluated using the ANP method. A network structure was formed showing the interactions and dependencies between the criteria. This network structure is given in Figure 3.

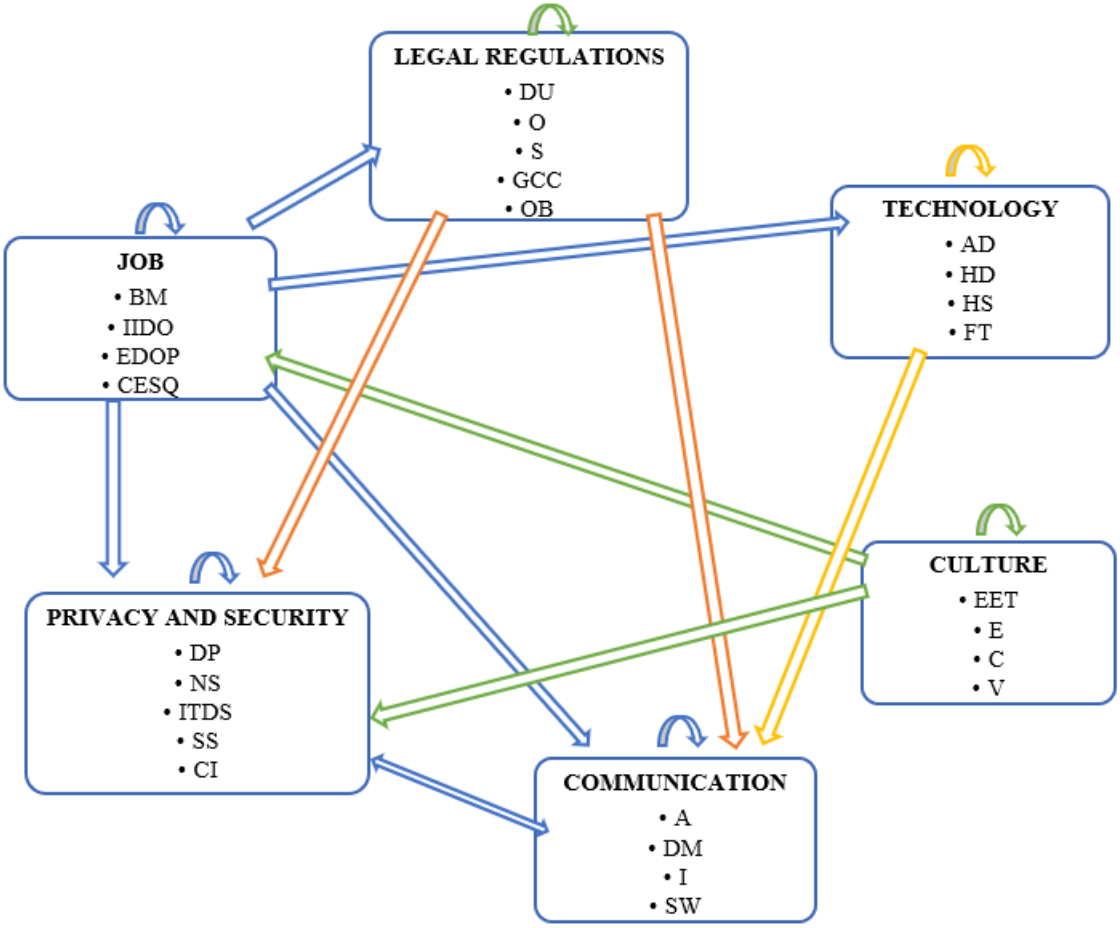

Figure 3. Network structure.

Internal dependence and external dependencies are shown in the network. When looking at the network structure in Figure 3, the management criterion affects network security, management security, security of devices, and data security criteria as the internal dependency. In the external dependency of the network structure, the main criteria, which are privacy and security and communication, affect other sub-criteria. The interactions between the criteria for the difficulties encountered in applying the Internet of Things were defined according to the studies in the literature and expert opinions. These binary comparison matrices were solved with the help of the Super Decisions packet program (2.10, University of Pittsburgh, Pittsburgh, PA, USA) (The sub-criteria weights obtained using the ANP method are shown in Table 6.

The weight of the criteria in Table 6 was examined and it was seen that the consistency ratio was lower than 1. In the ANP method, it was seen that the most important criterion was the hardware structure criterion. According to the results, the hardware structure criterion was in first place with 52.6%, whereas the vandalism criterion was at the bottom of this ranking with 7%. The standardization criterion comes after the hardware structure criterion, with 32.5%. Considering the importance of these criteria is essential when choosing which criteria should be used. Interactions and dependencies that are not considered in the AHP method were taken into consideration in the ANP method. Given the fact that the criteria depend on each other, when an enterprise takes into account the hardware structure criterion, the standardization criterion that is dependent on this criterion and the business model criterion based on the standardization criterion will be shown. Looking at the interdependence of the criteria found in the network structure, an enterprise will see that the business model will be affected by other criteria that depend on the criteria.

Table 6. Degree of importance of the sub-criteria.

Criteria	Criteria Weight	Criteria	Criteria Weight
NS	0.175	**E**	0.426
ITDS	0.210	**C**	0.368
DP	0.188	**V**	0.069
SS	0.235	**EET**	0.137
CI	0.192	**HD**	0.094
A	0.370	**HS**	0.526
I	0.327	**FT**	0.250
DM	0.106	**AD**	0.130
SW	0.197	**S**	0.325
EDOP	0.214	**DU**	0.101
BM	0.275	**O**	0.165
CESQ	0.245	**GCC**	0.224
IIDO	0.266	**OB**	0.185

5. Recommendations

In recent years, trials in relation to the Internet of Things have been common in Turkey, as the concept becomes increasingly more important. The transition to the concept of the Internet of Things for medium-sized enterprises located in Turkey has been hampered by extensive problems. Enterprises that did not have sufficient equipment and knowledge decided to postpone this transition process. In contrast to other studies, this study determined the factors that are causing the difficulties faced by medium-sized enterprises in Turkey in relation to the Internet of Things. At the same time, it should be noted that the importance of these factors varies on a company basis.

Today, in the face of the technological situation, all small, medium, and large enterprises must keep up with technology. Therefore, with the transformation to Industry 4.0 and IoT structures, enterprises will be able to grow faster and have a better rate of survival than their competitors. The adoption of the IoT concept by medium-sized enterprises ensures that they can survive in the developing technology market. Through this study, enterprises wishing to switch to the Internet of Things will more easily identify the difficulties they face and can incorporate these into their surveys and evaluations of their experts or employees. They will be able to accelerate the transition to the Internet of Things by addressing the identified factors.

The medium-sized enterprises in Turkey are structurally similar to each other. Thanks to the importance of this study and its contribution to the literature, enterprises wishing to take the example of the application made within the scope of the study will not be forced into the process of transitioning to the Internet of Things. This will result in a faster process. There are studies in the literature on the concept of the Internet of Things and the difficulties encountered in their countries. However, with this study, the factors affecting the difficulties faced by medium-sized enterprises, (i.e., enterprises operating in the Internet of Things) were identified. As it is known, the activities carried on by enterprises in the external world are very different. Therefore, this study develops a company-based perspective in the literature. As a result of the study, the difficulties encountered by a company in relation to the Internet of Things were determined. In addition, the importance of the different criteria was determined. Thanks to this study, the criteria which should be taken into consideration by companies struggling with the Internet of Things were brought to the forefront. At the same time, recommendations were made on how companies can evaluate these criteria. In this way, companies will have fewer problems and will be helped to prevent the difficulties encountered. In future studies, the significance of the criteria can be determined by fuzzy methods. By ordering the criteria, it is possible to determine the sorting order of the companies.

6. Conclusions

Nowadays, interactions and communication between objects play a more active role rather than human interaction. Companies think that the increase in Internet usage and communication between things will increase the number of jobs and the level of competition. Enterprises that aim to utilize the Internet of Things correctly should order the importance level of the difficulties that may be encountered, which can help detect the causes of the difficulties beforehand and complete the job with less hardship.

In this study, a medium-sized company located in Turkey was discussed, focusing on problems related to the Internet of Things. The difficulties encountered were identified as criteria and evaluated by experts. There were six main criteria—communication, technology, business, privacy and security, legal regulations, and culture—which affected the difficulties related to the Internet of Things. There were 26 sub-criteria: addressing, data management, infrastructure, software, architecture and design, heterogeneity of devices, hardware structure, fault tolerance, data privacy, network security, Internet of things device security, software security, conflict of interest, business model, investing in Internet development of objects, economic development opportunities and problems, customer expectations and service quality, data usage rate, ownership, standardization, global cooperation of the company, obligation, ethics of education and teaching, ethics, confidence, and vandalism. As a result of the study, the criteria that led to the difficulties they experienced during their transformation to IoT processes in a medium-sized enterprise were determined. The importance degree of the criteria was calculated by using the AHP and ANP methods. According to the results of AHP, it was seen that an enterprise which was undergoing the IoT process should pay attention to technology, communication and privacy, and security criteria. When the ANP ranking was considered, it was determined that the criterion of hardware structure should be taken into consideration because of the interaction of the criteria with each other. Considering the importance of the criteria obtained in the AHP method, the top three criteria are technology with 38%, privacy and security with 25%, and communication with 16%. The architecture and design sub-criterion, which is under the technology criterion, ranks first with 17.5%, followed by the heterogeneity of devices and network security. In the ANP method, the dependence and interactions of criteria were determined. If the company takes precautions and develops taking into account the other criteria that affect the difficulties encountered in the transitioning to the Internet of Things, it is anticipated that there will be fewer problems. As a result of the implementation of the ANP method, the hardware structure criterion is first with 52.6%. The ANP method will affect the criterion of the hardware structure as a result of the standardization criteria and other criteria that depend on the standardization criterion. It will be influenced by the main criteria such as technology and privacy and security, which depend on these sub-criteria. According to the results obtained, and to pay attention to objects between transmission in Turkey, the architecture and design of instruments and devices to provide devices with a different transmission must be given to the heterogeneity sub-criterion. In order to minimize the theft of information while providing transmission between things, it is important to have a high level of network security.

In studies in the literature, the concept of the Internet of Things, historical development, and the technological situation in companies have been emphasized. In the studies examined, the importance of the strategies to be taken into consideration in the transition to Industry 4.0 and the difficulties encountered related to the Internet of Things have been determined according to the country where the study was conducted. In this study, a medium-sized enterprise in Turkey that works with the Internet of Things was considered. The factors affecting the difficulties encountered by the identified company in the Internet of Things were discussed. The importance of these factors should be taken into consideration. In addition, the interdependence of the factors affecting these identified difficulties was evaluated by experts. Suggestions were made for companies on which factors should be considered and their order of importance.

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