



Several Factors to Analyze the Issues Concerned with the Internet of Things: Methods and analysis

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Abstract

The fast advancement of technology has contributed to a rise in everyone's demand to be connected to the internet. The Internet of Things is a notion that emerged with the fourth industrial revolution as a result of the finding that things that were born of the Internet can connect without the need for external causes (IoT). The communication of items with one another ensures that firms will spend as little time and money as possible on labor. Businesses that want to make the switch to the Internet of Things are going to run across a lot of challenges. The process of identifying and fixing these issues may result in both time and financial waste. Within the scope of this research, we looked at the challenges that are associated with the IoT. As a consequence of the research, the level of relevance of the elements that are generating these challenges was figured out using multi-criteria decision-making (MCDM) procedures, and the findings were given to the businesses. We decided on the primary criteria, as well as the secondary criteria that are connected to these primary criteria. The communication of different objects with one another is the primary goal of businesses that are making the shift to Industry 4.0. The purpose of this research was to identify the factors that contributed to the challenges encountered throughout the evolution to Industry 4.0. In the next step of the MCDM process, the DEMATEL approach was used to evaluate the level of significance associated with each of the factors. As a result of the research, we were able to establish which factors should be regarded as important for businesses that are interested in making the shift to the IoT. In this approach, businesses will be able to speed up the transition while limiting the amount of time and money lost in the process.

Keywords: Decision Making; IoT; MCDM; DEMATEL; Internet of Things

1. Introduction

Even though the IoT has been around for a long time, it is now considered to be an integral aspect of the idea behind the fourth industrial revolution, which is known as Industry 4.0. James Watt is credited with inventing the advanced charcoal-powered steam engine, which is regarded as the starting point of the industrial revolution. Subsequent developments include the use of electrical and oil in mass manufacturing. In the years that followed, as people started using the internet more often, we finally arrived at the concept of the IoT[1], [2].

The IoT is a network connecting items that may be handled uniquely because the things on that internet interact using a common protocol. This network is described as the IoT. Although there is no standardized architecture for the IoT, there exist architectural frameworks that are quite comparable to what have been described in published works. The IoT refers to the practice of transmitting

information from one thing or device to another using the analog or numerical data that an object or device obtains from its surrounding environment[3]–[5]. Enhancing the level of compatibility across different physical devices makes it feasible to have this feeling of connectedness. Investigation on how this link came to be was carried out by Androec et al. and may be found in the published works. This study also included a summary of the studies that focused on the compatibility of the IoT. Lelli infused the idea of Industry 4.0 with the notion of "smart interconnection" and underlined that this linkage could be accomplished with the help of the IoT[6], [7].

Using the concept of the Internet of Things, we can classify information into four distinct layers: the surroundings, the device or item, the transfer, and the software and the information. The goal of this part of the process is to figure out what kinds of information the equipment or items will provide. Businesses will have the ability to exercise control over the applications of Industry 4.0 and the internet of things in the manufacturing or service activities they undertake. These procedures will be able to be measured and controlled inside their businesses. Companies that are not on the cutting edge of these developments will not be able to compete successfully in the future business landscape. The adoption of Industry 4.0 is necessary because of the technical and digital shifts that are occurring in the consumer and manufacturing processes[8], [9].

The transformation process that businesses must go through is not without its challenges, however, as is the case with any new procedure. One of these challenges is that the infrastructure that is necessary for the transition process does not currently have sufficient capacity. In addition to this, one of these issues is a lack of awareness of the behavior of customers, as well as a lack of readily accessible resources to fulfill customers' requirements. Some of the challenges that will be faced by businesses in the future include social issues such as the insufficiency of R&D studies, information contamination or a lack of knowledge, and the possible increase in employment that is related to robotic procedures. There is a risk that businesses that do not have staff who are educated in digitalization will harm Industry 4.0[10]–[12].

The importance of having access to the Internet is steadily growing as a result of the fast development of today's technologies. Because of the advances in technology that have been made in recent years, the IoT, which was first introduced with the idea of Industry 4.0, now plays an essential role for businesses. Because of this, every business that wishes to maintain a presence in the market must make the shift to the IoT. During this period of change, the challenges that the companies face are both financially burdensome and time intensive[13], [14].

Within the scope of this research project, an investigation of the challenges posed by the IoT was carried out. The criteria were established with the assistance of the views of industry professionals and research conducted by Mohammadzadeh. It was determined based on the primary criterion as well as the secondary criteria. Methods such as the DEMATEL was used to calculate the relative importance of each criterion. Interaction, innovation, economics, safety and security, legal laws, and cultural norms are the primary elements that are taken into consideration.

The criteria that were determined include data processing, infrastructural facilities, apps, design, and architecture device homogeneity, hardware framework, flexibility, confidentiality of information, information security, Internet of gadgets, protection of devices, malware protection, conflict of interest, marketing strategy, making an investment in the development of the IoT, economic career progression and difficulties, client needs and customer satisfaction, data utilization rate.

The incorporation of applications related to Industry 4.0 into businesses operating in the industrial sector offers an opportunity to grow the client base. In particular, applications that are generated during manufacturing make the production process shorter and simplify the procedures that go along with it. They also improve the company's internal communication and the way employees connect [13], [14].

Fera et al. looked at previously completed research in addition to newly discovered viewpoints on production processes to figure out the issues that were occurring throughout the manufacturing processes. Therefore, applications of Industry 4.0 that are shown in that research and allow information interchange are disruptive to the operations of businesses. There is a possibility that implementing the applications of Industry 4.0 in businesses would be fraught with difficulty.

The firms can exert more control over the process of transition as a result of the identification of the variables that are contributing to these issues. Additionally, it makes that shift easier. In situations like this, a number of possible strategies might be used for the task of analyzing the requirements in the

research. Methods of making decisions based on many factors might also be useful tools for carrying out this sort of study. In this investigation, the DEMATEL method, both of which are approaches to decision-making that take into account several factors, were used for their respective strengths.[15]–[17]

2. Internet of Things (IoT)

For the last couple of years, people have been familiar with the phrase "Internet of Things," abbreviated "IoT." Page Rank guesstimate has turned out to be extremely helpful for locating Web pages, and the rank results of Web pages can be governed. As of late, it has been receiving more attention because of the advancement of remote technology, and web-based meetings have been allowed to be important spots for individuals to search for law enforcement agencies on the web. In addition, The control problem is also known as the Webspam problem, which refers to clickable sites on the World Wide Web that are created with the intention of misleading web crawlers.

The explanation for why there is an expanding amount of Web spam can be found in the way that some website administrators endeavor to influence the organizing of their webpage indoor filed records. This is done because of the enormous proportion of web activity that originates from inquiries, as well as the high potential monetary best estimate of this activity, which incorporates PageRank on this enormous size casual connection. This is done with the specific objective truth of recognizing clients. Data arrangement analysis has evolved into web group disclosing, scaremonger network mining, personal computer network investigation, and acknowledgment of system interruption as a means of resolving the management issue and gaining a new perspective on the architecture of the Internet as a result of Google and other suitable web search tools. This is necessary to address the control issue and to account for the impact of these developments on the Internet. In any case, research into data networks needs to go beyond explicitly formed, homogenous systems (such as webpage joins, Computer devices, and fear alarmist association organizes), and instead develop and verifiably shape heterogeneously shaped, multiple database systems[15]–[20].

Using the DEMATEL technique, the step was to make a list of the factors impacting the degree of significance of the challenges that were experienced with the Internet of Things[21]–[23].

3. DEMATEL Method

DEMATEL is a form of structural modeling method that helps analyze the cause and consequence linkages among the elements of a system. This analysis may be done by looking at the system as a whole. DEMATEL is a tool that may be used to validate the presence of a connection or dependency between components, as well as represent the relative amount of connections that exist within those elements[24]–[26].

Step 1: Select a group of knowledgeable individuals

The selection of the most qualified professionals available in the management, buying, and arrangement of contracts is the first phase of the DEMATEL technique. We chose three professionals, who will be referred to in the following the first specialist, the second specialist, and the third specialist, respectively.

Step 2: The second step is to identify the primary standards and procedures.

Step 3: Comparison matrices among important criteria using a pairwise approach.

Step 4: Initiate the creation of the direct relation matrices.

The preceding step (4), which consisted of merging all of the averaged viewpoints of experts, is what led to the creation of this matrix. An initial direct relation matrix, denoted by the letter A, is a n by n matrix that is derived by pairwise comparisons, denoted by the equation $S = [s_{ij}]_{nm}$. The value of the symbol x_{ij} indicates the extent to which the criteria I have an impact on criterion j.

Step 5: The direct relation matrix will now be normalized.

The equation that may be used to get the normalized direct relation matrix is as follows:

$$H = \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^n x_{ij}} \quad (1)$$

$$E = H \times X \quad (2)$$

Step 6: achieving the whole relational matrix.

To complete this stage, you will need to utilize the Matlab program. The generalized direct relation matrix S is used as a starting point to derive the formula (3) for obtaining the total relation matrix. The following is an example of a total relation matrix denoted by the letter "R," in which "D" stands for the identity matrix:

$$R = E \times (D - E)^{-1} \quad (3)$$

Step 7: Obtain the total by adding up the rows and the columns.

The total number of rows is represented by the letter (W), whereas the total number of columns is represented by the letter (C). Compute $W + C$ and $W - C$.

$$W = \left(\sum_{i=1}^n x_{ij} \right)_{1 \times n} \quad (4)$$

$$C = \left(\sum_{j=1}^n x_{ij} \right)_{1 \times n} \quad (5)$$

Step 8: Create a graphic showing the causes and effects

The causal diagram may be constructed by using the horizontal axes, which are provided by $(W + C)$, and the vertical axes, which are $(W - C)$, which is a degree of connection. This diagram represents the stages of the suggested model in Figure. 1.

Step 9: Compute the weights of criteria (IoT criteria)

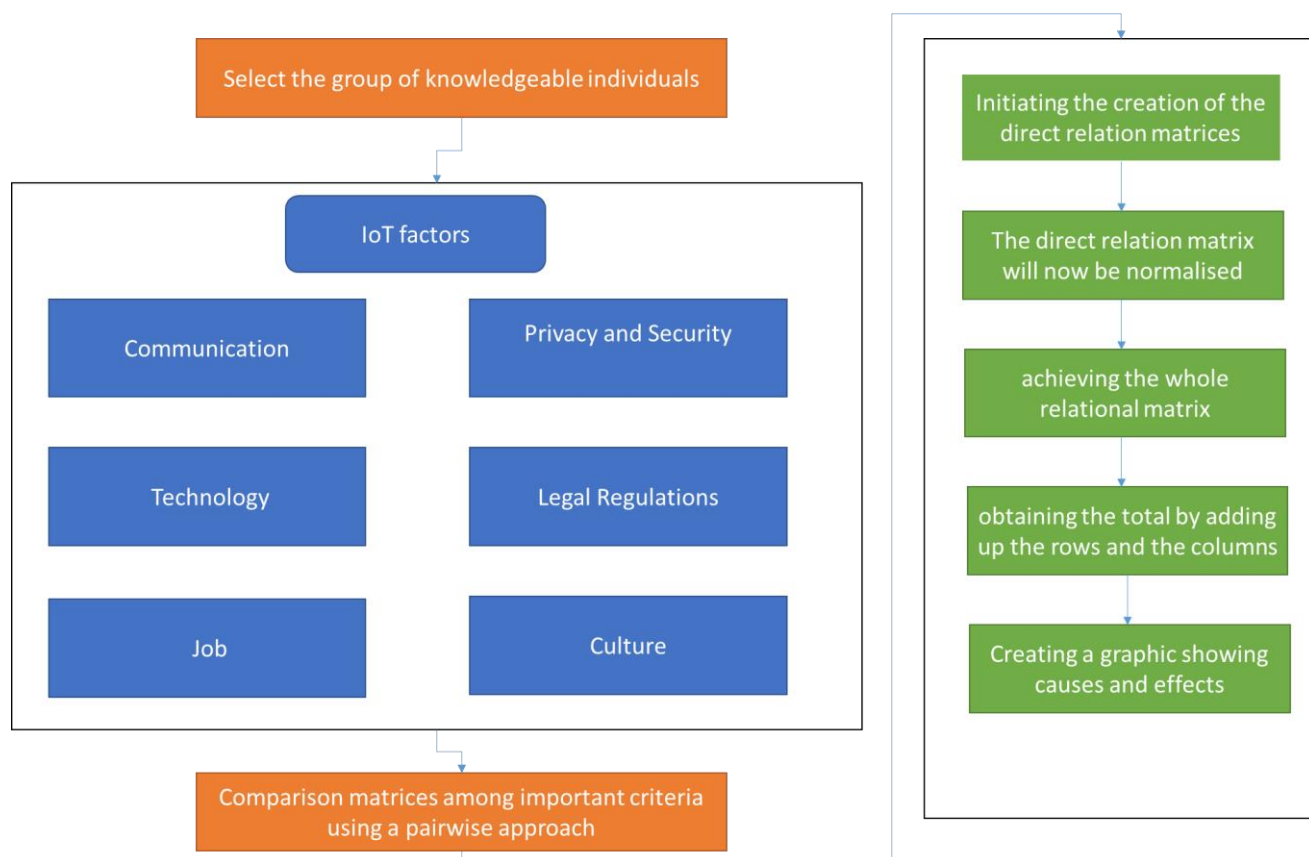


Figure 1: The framework for analyzing the issues concerned with IoT

4. Results

In the course of this research project, the challenges that medium-sized businesses face in terms of technological development with the IoT were analyzed. Through an analysis of the relative weight of various criteria, the purpose of the research was to evaluate the challenges involved in the process of building Internet of Things technology. The parameters that should get special attention were brought to the forefront of the discussion. The application domain was a medium-sized business, and among those businesses, one that was in the process of making the switch to technology based on the IoT was chosen for this discussion. The views of knowledgeable individuals were solicited to analyze the study's criteria.

Select a group of knowledgeable individuals. A group of experts evaluated the criteria. In this paper, there are three experts to evaluate the criteria to show the weights of factors. Then identify the factors. In this paper, there are six factor to be analysed. These factors are organized as follows: Communication (IoTC1), Technology (IoTC2), Job (IoTC3), Privacy and Security (IoTC4), Legal Regulations (IoTC5), and Culture (IoTC6). Then let three experts to evaluate these factors to build three comparison matrix. So, we have three experts by their opinions. Then aggregate the opinions of experts by the average matrix to obtain one matrix. Then build the direct relation matrix by the aggregated comparison matrix. The direct relation matrix shown in table 1.

Table 1: The direct relation matrix

	IoTC1	IoTC2	IoTC3	IoTC4	IoTC5	IoTC6
IoTC1	2	6	5.333333	8.333333	6	6
IoTC2	4.666667	4	4.666667	5	6	8.666667
IoTC3	4.666667	5	4	7.666667	8	7
IoTC4	5.333333	3.666667	4.666667	5	5.666667	5.333333
IoTC5	5	5	6.666667	4	5	4.666667
IoTC6	3	6	7	6.666667	4.333333	4.333333

From the direct relation matrix, create the normalization matrix. Normalized direct relation matrix using Eqs. (1,2). The normalized matrix is shown in table 2.

Table 2: The normalization direct relation matrix

	IoTC1	IoTC2	IoTC3	IoTC4	IoTC5	IoTC6
IoTC1	0.375	1	0.761905	1	0.75	0.692308
IoTC2	0.875	0.666667	0.666667	0.6	0.75	1
IoTC3	0.875	0.833333	0.571429	0.92	1	0.807692
IoTC4	1	0.611111	0.666667	0.6	0.708333	0.615385
IoTC5	0.9375	0.833333	0.952381	0.48	0.625	0.538462
IoTC6	0.5625	1	1	0.8	0.541667	0.5

Using the Matlab software to obtain the total relation matrix. From the normalized direct matrix, the total normalized direct matrix is obtained. The total relation matrix is obtained using Eq. (3). Table 3 shows the total relation matrix.

Table 3: The total relation matrix

	IoTC1	IoTC2	IoTC3	IoTC4	IoTC5	IoTC6
IoTC1	-0.46745	-0.1418	-0.23363	-0.04299	-0.20014	-0.19207
IoTC2	-0.21191	-0.31807	-0.2484	-0.30236	-0.24396	0.034303
IoTC3	-0.1928	-0.30251	-0.42538	-0.1578	-0.07983	-0.22393
IoTC4	-0.00304	-0.3216	-0.23549	-0.22192	-0.16398	-0.24676
IoTC5	-0.10422	-0.18476	-0.07255	-0.3824	-0.247	-0.29073
IoTC6	-0.32809	-0.11541	-0.06576	-0.13802	-0.31934	-0.30511

Obtain the total score by adding up the rows and the columns. The sum of rows and columns is computed using Eqs. (4,5). Then create a graphic showing the causes and effects. The weights of the criteria are computed. The weights of criteria are organized as follows: $w_1=0.17$, $w_2=0.20$, $w_3=0.18$, $w_4=0.146$, $w_5=0.153$, $w_6=0.149$. The technology is the highest weight followed by the privacy and security.

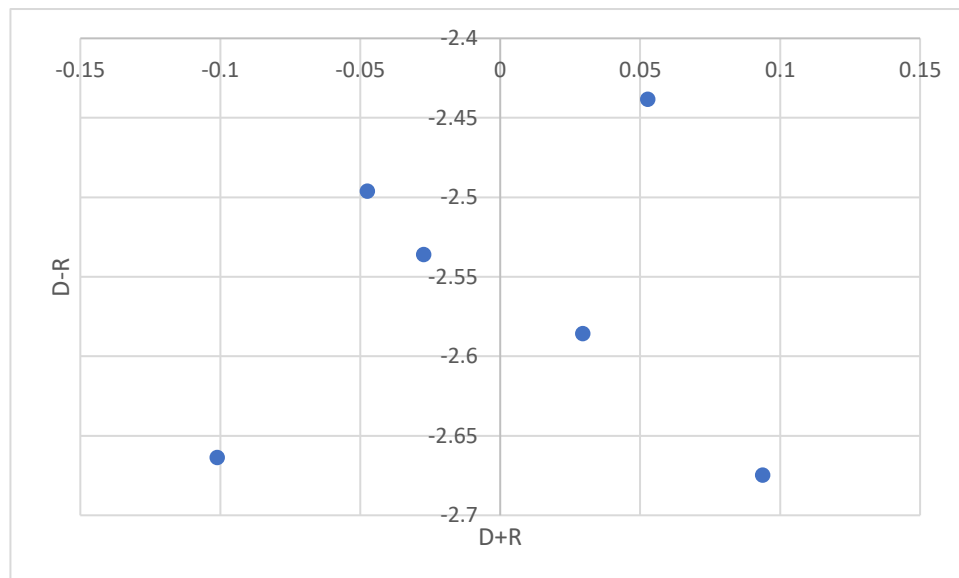


Figure 2: The cause effect diagram.

From figure 2, the technology criterion has a highest impact in the all criteria followed by the security and privacy followed by the communication. Figure 3 shows the effects criteria.

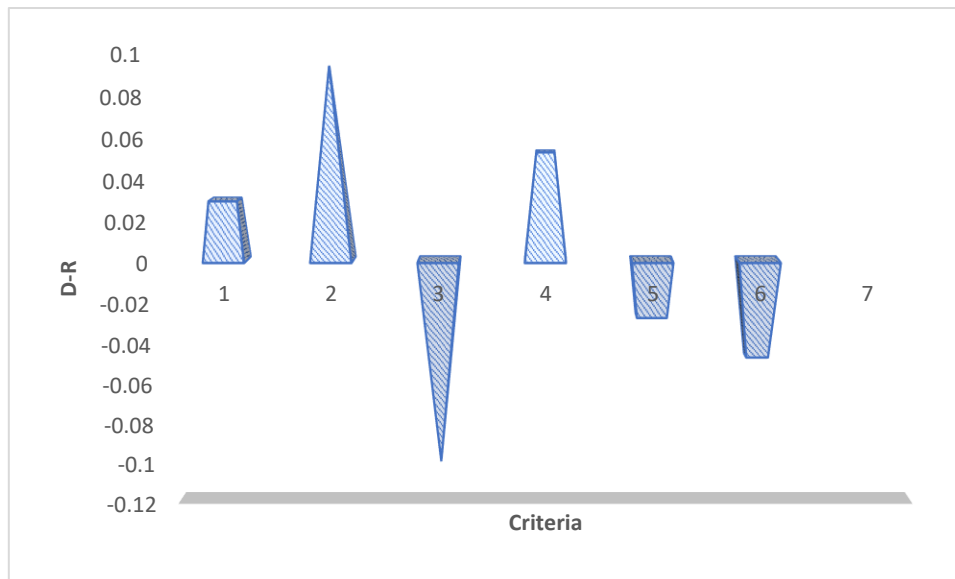


Figure 3: The effect of six criteria.

5. Conclusion

At this point, human engagement is becoming less important than the interactions and communication that take place between things. Many businesses believe that a rise in the number of people using the internet and the communication that occurs between objects would lead to an increase in the level of competition as well as the number of available employment. Businesses that are serious about making effective use of the Internet of Things should prioritize the severity of the challenges that they anticipate facing. Doing so will enable them to identify the root causes of those challenges in advance and finish the task with far less effort.

In the course of this research, the challenges that are associated with the Internet of Things were analyzed in the context of a Turkish firm of medium size. The challenges that were experienced were used as criteria, and those criteria were examined by specialists. There were primarily six factors that contributed to the challenges that were associated with the Internet of Things, and these were communication, innovation, commerce, safety and security, legal laws, and culture. The findings of the research allowed for the identification of the factors that contributed to the challenges that were encountered by a medium-sized business throughout the process of transforming its operations to include IoT. The DEMATEL method was used to arrive at an estimate for the significance level of the criterion. According to the findings of the DEMATEL, it was discovered that a business that was in the process of implementing IoT needed to pay attention to technological, communication, and privacy standards, as well as security standards.

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