Adoption of Industry 4.0: A case of manufacturing firms in Turkey

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***Abstract*— The fourth stage of industrialization that is called as Industry 4.0, is digitalization of manufacturing. Cloud technologies, The Internet of Things (IoT), and Cyber-Physical Systems (CPS) are some of the technologies that help to make manufacturing digitalized. Although these first applications were seen in Germany, some studies indicate that manufacturing firms from developing countries have started to use Industry 4.0 technologies. These firms are mostly aware that disregarding benefits of Industry 4.0 technologies may result with falling behind in global rivalry. Turkey is one of these countries, and it has firms that are aware of advantages of using these technologies. The goal of this study is determining the adoption level of Industry 4.0 in manufacturing firms of Turkey. Some questions whose answers will be taken from the firms by a survey, are as follows: Is your firm aware of Industry 4.0 concept and its technological benefits? Which technologies are used and how do these technologies affect your productivity and costs? What are the challenges for adoption of Industry 4.0?**

***Keywords*— Digitalized manufacturing, Industry 4.0, Turkey, survey, manufacturing industry**

I. INTRODUCTION

The invention of the steam engine in 1976 is assumed as a starting point of industrialization [1]. Also, the era between 1976 and the beginning of the 20th century was the first stage of industrial revolution in the manufacturing industry. After that time, some revolutions have occurred via new inventions that directly affected manufacturing industry. At the beginning of the 20th century, electricity was started to use instead of steam [2]. In addition to this, assembly lines started to be preferred in manufacturing. The period in which these important developments took place was known as the second industrial revolution era. After that time, with the use of electronics started the third industrial revolution and production automated thanks to the development of the information technologies. And after years, the fourth industrial revolution began with the introduction of production based on Cyber Physical Systems (CPS). This concept which leads to the start of a new era was first introduced in 2011 at the Hannover Messe trade fair in Germany and attracted the attention of the world. The main topic of 2016 World Economic Forum's meeting held in Davos was "Mastering the Fourth Industrial Revolution" [3].

A. What is the main reason of that Germany needs to introduce such a concept?

While Europe's industry has faced some problems in the past two decades, Eastern countries, especially China, have become advantageous in terms of low production cost. Eastern countries have started to create their own brands in addition to low-cost production. This situation started to disturb Germany which is one of the European countries. The low-production cost in flexible manufacturing must be achieved to compete with Eastern countries. Because of these reasons, Germany started to search new technologies which lead industrial 4.0 revolution.

B. What is Industry 4.0?

Industry 4.0 is a complex system including whole technological systems [4]. More recently, Industry 4.0 provides many new technologies to a lot of fields. We can gather these technologies under the following headings.

- Cyber-Physical Production System (CPPS): It's the most important technology in the industry 4.0. It's the integration of physical systems and computer systems. CPPS is the first phase of industry 4.0. After this phase, the system is developed to adapt to Industry 4.0.
- Internet of Things (IoT): This concept is firstly introduced by Kevin Ashton in 1999. IoT is a technological scenario in which can transfer data to a local network or an internet network without the need for human-human and human-computer interaction [5]. The first technology created by loT is radio frequency identification (RFID).
- Cloud Computing Technology: Cloud computing is a model of access to information on the internet. In such a model, users reach various computing services, like storage, computing and, various applications, but they don't know where this information is stored, on what servers it is run, and how it is structured technically [6].
- Augmented Reality: An augmented reality system supplements the real world with virtual (computer-generated) objects that appear to coexist in the same space as the real world [7].

Companies can take the advantages of these technologies. Some examples of them given as follows:

- Applications and equipment in which big data technology used that allow remote viewing can be purchased. These are the projects generally preferred in universities [8] [9].
- Companies have just begun to adopt additive manufacturing, such as 3-D printing, which they use mostly to prototype and produce individual components [10].
- While employees are working, they can both make mistakes and cause a loss of time. But this is not the case with smart operations [11].

When the benefits of Industry 4.0 is considered, it can be recognized that it is very important for companies to adopt Industry 4.0. They should prepare themselves for Industry 4.0 for their own benefits and develop self-control systems to take the necessary precautions by analyzing the indicators.

II. LITERATURE REVIEW

In the literature, we could find three studies that are similar with this study.

The first is done by PwC which is a global consulting firm. The result of the survey is presented in a report named as "Industry 4.0: Building the digital enterprise". More than 2000 industrial companies from 26 countries are participated in the survey. The result of the survey shows that 33% of the companies reached advanced levels of digitization today and 72% of the companies expect to reach advanced levels of digitization by 2020 [12]. The second of the surveys is conducted by Boston Consulting Group (BCG). BCG, which is a global management consulting firm, prepared a report entitled "Time to Accelerate in the Race Toward Industry" in 2016. The result of a survey answered by more than 600 managers and senior executives representing 312 German and 315 US companies is given in this report. The aim of the survey is to see the status of adoption of Industry 4.0 in Germany and the US. According to this survey results, German and US companies are at almost the same pace in terms of implementing Industry 4.0 technologies. But, German companies have higher ambitions. One of the findings of the survey is the biggest challenges of implementing Industry 4.0 are lack of qualified employees, data security, and excessive investment requirement of new technologies [13].

The third study is a thesis that written in Turkey and it is similar with our study. But, in this study, the writer of thesis addressed 74 questions to the 5 firms in Sakarya that is a city in the Marmara Region of Turkey. One of the results of this study is that the concept and applications of Industry 4.0 are not yet fully understood so that efficiency taken from this concept is at the initial level [14].

Until here, the situations of the some countries in Industry 4.0 race have been given. If we look at the studies- that we can find on the web- related to Industry 4.0 have been performed in Turkey, it can be seen that they are promising. For example, a group was formed in order to determine the road map of Turkey under the leadership of TUSIAD that stands for Turkish Industrialists' and Businessmen's Association. A website, http://www.endustri40.com/, is dedicated to Industry 4.0, aims to share useful information about this concept and help the digital transformation of Turkey manufacturing industry.

Although, as mentioned above, the studies have been made to increase Industry 4.0 awareness of Turkey manufacturing industry, the effectiveness of these studies should be measured in a variety of ways. For this reason, the adoption level of Industry 4.0 in manufacturing firms of Turkey is tried to determine by this study. A survey is conducted and key findings are presented in the next section named as Analysis of Survey Results.

III. ANALYSIS of the SURVEY RESULTS

The survey that concludes 20 questions is sent to over 100 firms from different sectors in Turkey. But, only 33 responses are taken. The questions and responses are given as follows:

1) Which sector does your company operate in? [12]

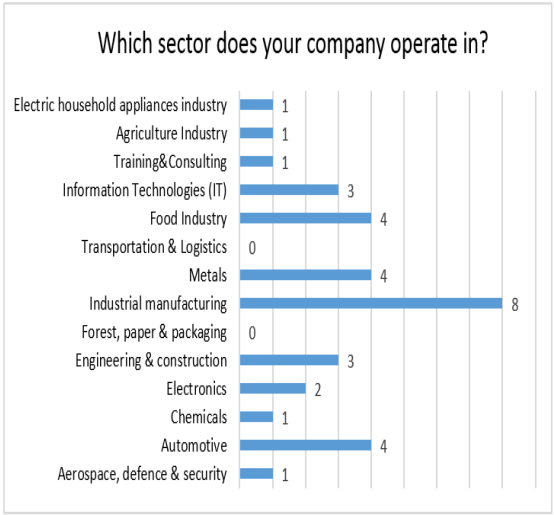

Fig. 1 Split of surveyed companies

The majority of the surveyed companies operate in industrial manufacturing. Automotive, metals, and food industry are in the secondary majority.

2) How can you classify your business by the number of employees?

Fig. 2 Classifying of surveyed companies by number of employees

Most of the surveyed firms have less than 250 employees and they are classified as Small and Medium Sized Businesses (SMEs).

3) Does your company have knowledge of Industry 4.0 technologies?

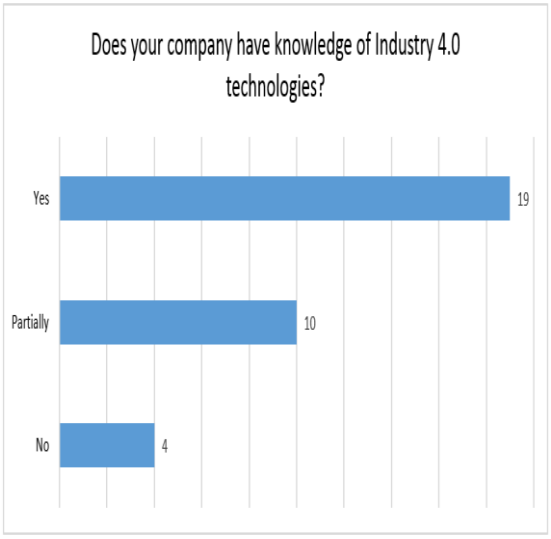

Fig. 3 Split of the responses of the third question

Over 50% of the surveyed firms say that they have knowledge of Industry 4.0 technologies. Only 4 firms doesn't have knowledge of this concept.

4) Has your company made any preparations for Industry 4.0 technologies? [13]

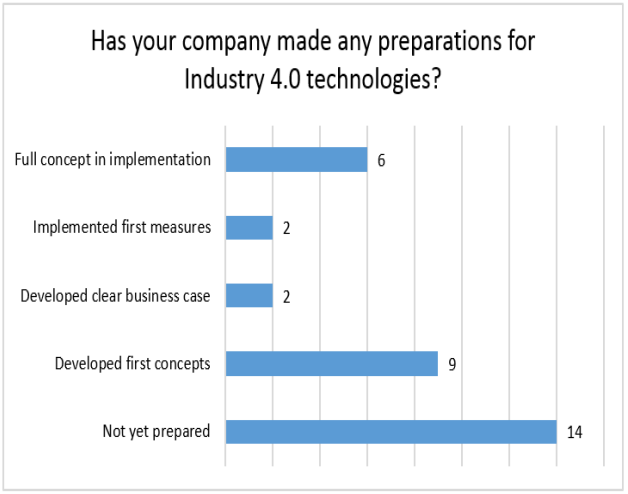

Fig. 4 Split of the responses of the fourth question

While 42% of the firms have not made any preparation for Industry 4.0 technologies, 27% of them have developed first concepts.

5) Which of the following applications are used by your company? [13]

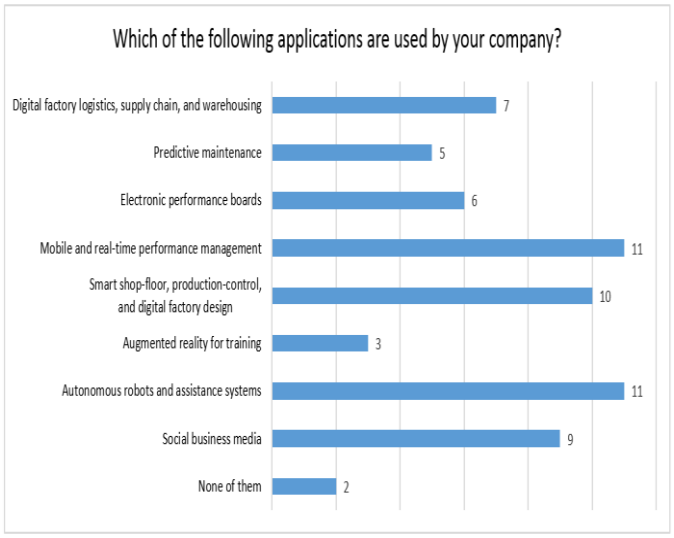

Fig. 5 Split of the responses of the fifth question

According to the survey results, autonomous robots and assistance systems, mobile and real-time performance management applications have been preferred mostly.

6) Which of the following applications are planned to be used by your company? [13]

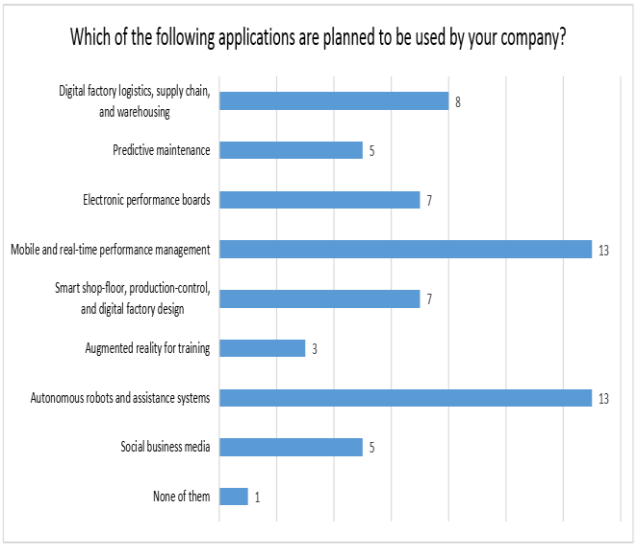

Fig. 6 Split of the responses of the sixth question

The surveyed firms are planning to use autonomous robots and assistance systems, mobile and real-time performance management applications.

7) *Which qualifications do you expect more your employees to have in the future?* [13]

Fig. 7 Split of the responses of the seventh question

In the future, the firms think that they will need employees that are qualified especially in data management, data security, programming, analytics, and control of manufacturing processes.

8) Which qualifications do you expect less your employees to have in the future? [13]

Fig. 8 Split of the responses of the eighth question

In the future, the surveyed firms think that they will need fewer employees that can perform manual processing.

9) How do you manage the changes in the required qualifications of your employees? [13]

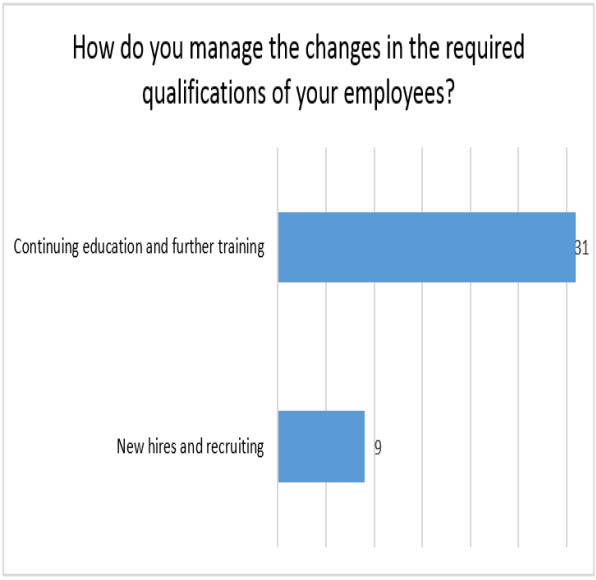

Fig. 9 Split of the responses of the ninth question.

Most of the surveyed firms prefer continuing education and further training to new hires and recruiting in the management of the changes in the required qualifications of their employees.

10) *What are the biggest challenges to implement Industry 4.0 concept for your company?* [12], [13].

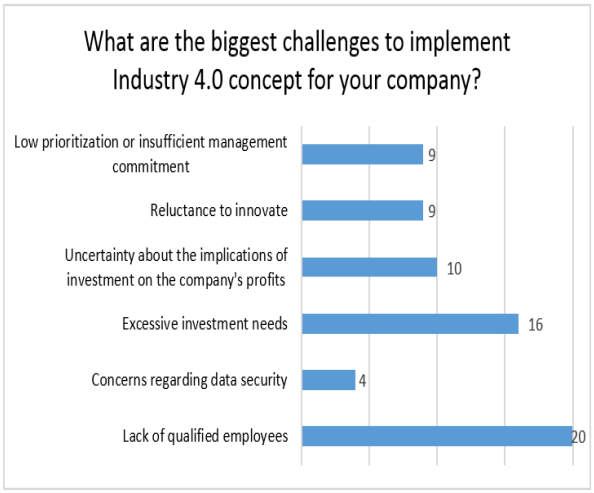

Fig. 10 Split of the responses of the tenth question.

According to the survey results, lack of qualified employees and excessive investment needs are the biggest challenges to implement Industry 4.0.

11) In the current situation, what is the amount of your firm's investment in digital technology? [12]

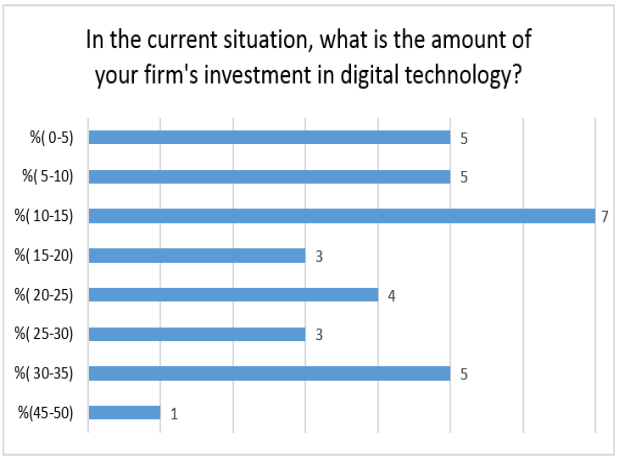

Fig. 11 Split of the responses of the eleventh question.

In the current situation, most of the firms say that amount of firms' investment in digital technology is less than 15% of annual revenue.

12) What will the amount of your firm's investment be in digital technology within the next five years? [12]

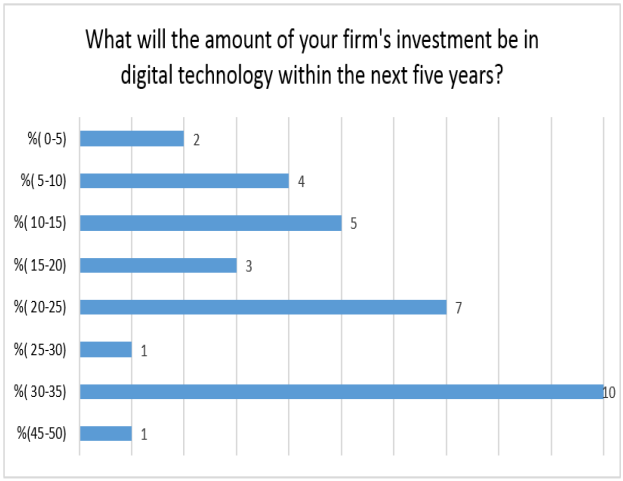

Fig. 12 Split of the responses of the twelfth question.

Over the next five years, most of the firms say that amount of firms' investment in digital technology will be more than 10% of annual revenue.

13) In your opinion, what are the benefits of digitized production? [12]

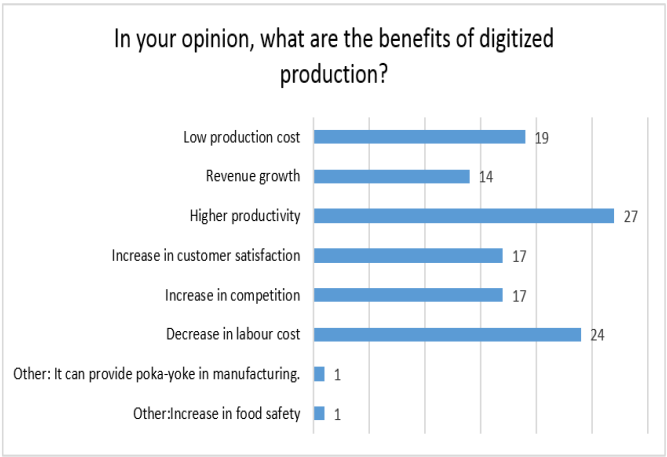

Fig. 13 Split of the responses of the thirteenth question.

According to survey results, low production cost, revenue growth, higher productivity, increase in customer satisfaction, increase in competition, increase in food safety, and decrease in labour cost are expected benefits of digitized manufacturing. Also, one respondent says that it can provide poka-yoke in manufacturing.

14) Do you think that digitized manufacturing has disadvantages? If your answer is "Yes", would you like to tell these disadvantages briefly?

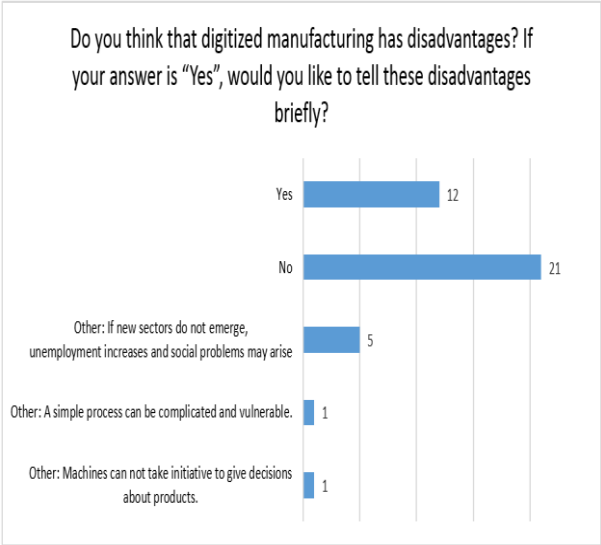

Fig. 14 Split of the responses of the fourteenth question.

Most of the surveyed firms do not think that digitized manufacturing has disadvantages. But, some of them think that it can increase unemployment rate and cause social problems. Also, one of the respondent says that machines cannot take initiative to give decisions about products.

15) Is your company planning to carry out studies on data analytics in the next 5 years? [12]

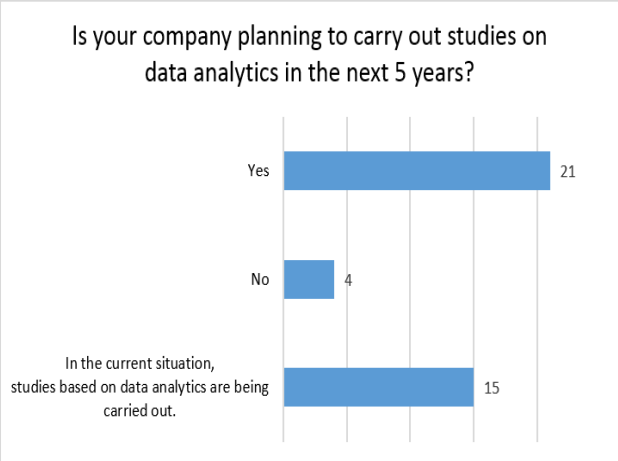

Fig. 15 Split of the responses of the fifteenth question.

Very few of the respondents say that they are not planning to use data analytics. Most of them is planning to use in the next five years and 15 respondents say that the studies based on data analytics are already being carried out.

16) In which areas is your company planning to use the data analytics over the next 5 years? [12]

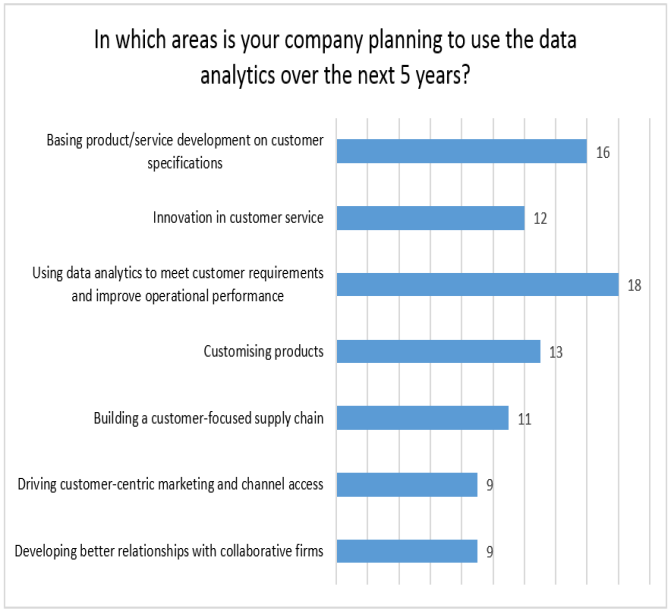

Fig. 16 Split of the responses of the sixteenth question.

According to the survey results, the firms are planning to use data analytics to meet customer requirements and improve operational performance.

17) What are your company's concerns about the data security? [12]

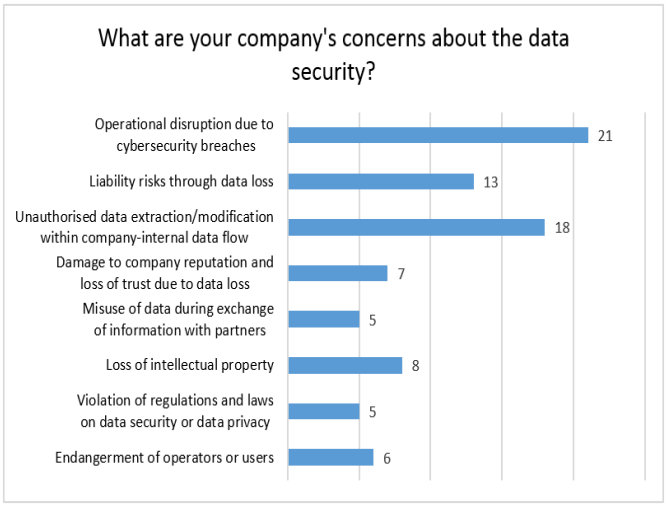

Fig. 17 Split of the responses of the seventeenth question.

Most of the surveyed firms have concerns about the data security. Operational disruption due to cybersecurity breaches and unauthorised data extraction/modification within company- internal data flow are most common concerns that the firms have

18) Do you think that Industry 4.0 technologies can cause problems that related to unemployment since labor-intensive manufacturing is reduced?

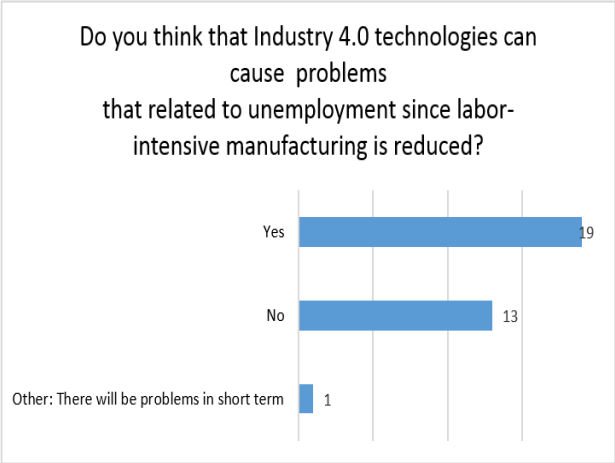

Fig. 18 Split of the responses of the eighteenth question.

58% of the firms think that Industry 4.0 technologies can cause problems that related to unemployment since labour-intensive manufacturing is reduced.

19) Do you think that Industry 4.0 would have a positive effect on the issues that are related to society like environment and health?

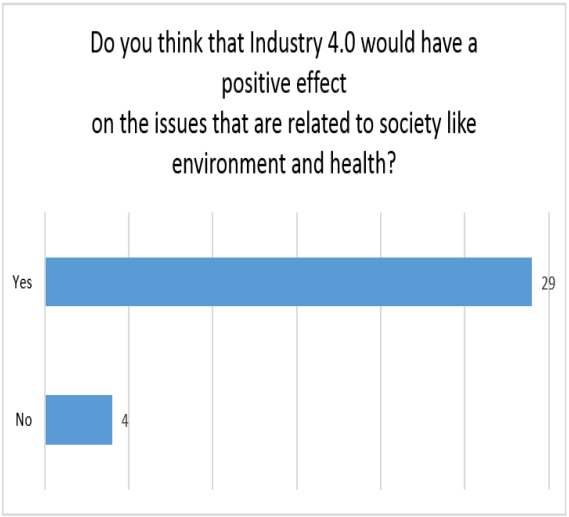

Fig. 19 Split of the responses of the nineteenth question.

Most of the surveyed firms think that Industry 4.0 concept would have a positive effect on the issues that are related to society like environment and health.

20) Do you have any comments that are not mentioned in the survey?

84.8% of survey respondents don't want to make any comments about Industry 4.0 concept. Some of the respondents' views are given as follows:

- "In terms of food safety, Industry 4.0 concept should not be neglected."
- "Industry 4.0 technologies can help to reduce production cost and increase productivity but using these technologies can cause unemployment. In order to prevent its adverse effects, some jobs should be kept doing by manually."
- "It seems that a large portion of the businesses in our country are not ready for Industry 4.0. If we want to be a developed country, the required works for Industry 4.0 should be performed in a widespread manner."

IV. CONCLUSIONS

However, we don't reach so many firms to conduct the survey, the answers show that the most of the firms that answer the questions are aware of Industry 4.0. Also, the studies tried to be carried out are promising for Turkey manufacturing industry.

It is admitted that challenges of the implementation of the Industry 4.0 technologies for Turkey firms are not limited with those that mentioned in this study. But, necessary precautions should be taken not to be left behind in the Industry 4.0 race by considering their pros and cons.

ACKNOWLEDGMENT

We used some questions and choices of the surveys of BCG and PwC in our research by citing properly.

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