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A Survey to Examine Engineers' Perspectives on Innovation and Industry 4.0 †

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Abstract: In parallel with the rise of Industry 4.0 and the developments experienced with digital transformation, there are striking differences in the concept of innovation in terms of process and effect. It is a fact that engineers have a strategic importance in transforming the changes and developments in the fields of informatics and technology, where great leaps have been experienced, into innovations in a way that creates value. Engineers examine the terms of perceptions and perspectives in this adaptation process and 120 engineers with different educational backgrounds in Turkey were surveyed in this study to assess the diversity of the innovative vision under examination. Statistical Package for the Social Sciences (SPSS)software was used for the stages of analysis.

Keywords: digitalization; Industry 4.9; engineers; innovative perception

1. Introduction

Turkey is an ever-growing country which has both economic and social improvement goals. In the year 2016, TUBITAK (Türkiye Bilimsel ve Teknolojik Araştırma Kurumu) presented an updated version of the 2023 vision objectives of Turkey and almost all of the targets listed were about improving our technology, using and benefitting from concepts of technology wisely, and leading in the production of new technology with the help of innovative knowledge [1]. For instance, by the year 2023 Turkey aims to be one of the world's main export countries and also wants to have its own domestic vehicle which is powered solely by renewable energy systems. In order to realize these objectives, one of the most effective and important factors is technology. It is important to consider that the most successful countries and/or companies follow and adapt to changes quickly. There are several possible ways of developing technology, but one of the most effective ways of implementing innovation in the workforce is through the use of Industry 4.0. It is said that through Industry 4.0, Turkey will reach its 2023 objectives in field of exportation [2]. The Industry 4.0 concept is about replacing manpower with machines and turning production processes into more controllable and manageable operation steps [3].

According to Şuman, with the implementation of Industry 4.0 Turkey will reach a new level of efficiency in production, competitive power, and sustainability [4]. Prior to discussing Industry 4.0 and its effect on Turkey, the meaning of Industry 4.0 should be discussed. According to Stock and Seliger, Industry 4.0 is the fourth stage of industrialization. It follows the developments carried out within the third chapter of industrialization back in 1970s. Unlike other sections of industrialization, Industry 4.0 bears a high level of automation and technology (2016:536) [5]. With the spread of the Industry 4.0

concept, new notions such as the internet of things, digitalization, big data, and autonomous applications have emerged. The internet of things can be explained as a giant network connecting entities from different fields, leading to smarter applications [6,7]. Digitalization can be exemplified as the conversion of knowledge into a digital environment. Additionally, big data is the result of data gathered from several traditional and digital sources on a subject from its environment [8]. In literature there are many properties provided for the concept of big data. When all of these features are gathered a concept named the multi-V model is retrieved. The multi-V model is formed through the volume, variety, velocity, value, and veracity characteristics of the big data. The volume feature stands for the vast amount of data generated every second. Variety is the different types of data gathered. Velocity is the speed at which new data is formed and transferred around the world. Value is the most important property of big data since it provides meaning to the acquired data. Last but not least, veracity stands for the trustworthiness and availability of the data [9,10]. Autonomous applications are the result of converting traditional manpower into remotely controlled and programmable machine applications, a good example of which is the implementation of autonomous robotic applications inside a factory [3]. The adaptation of such innovative notions into reality can be considered as one of the most crucial disciplines is the engineering field, since innovation also contains the application of opinions. For instance, as stated by de Jong and Hartog, employees can be helpful when it comes to the improvement of work performance via their ability to form and create new ideas, projects, and concepts. Thus, through the notions and practice of individual innovation, organizational success and improvement can be achieved. To see, recognize, and be a part of novelty, employees should be open to and be able to perform innovation-related actions [11]. As expressed by Albayrak Serin and Yılmaz Yalçıner, for a country to compete with others in the field of innovation, its engineers should be innovative and keen on self-innovativeness [12]. Innovation can also be described as the process of forming valuable products from creative opinions for business usages [13].

Moreover, innovation can also be elaborated as improving present technologies with the help of science, industry, and employees in order for them to reach a new level [14]. When it comes to our country, with the aim of following, understanding, and applying novel ideas, Turkish engineers should be sensitive and open to innovation. The relation between engineering and innovation has always been an important topic for the academic world and industry [12]. This study aims at to gather information about the perceptions of Turkish engineers toward innovation, Industry 4.0, and other novelty related concepts. The results reached are compared to studies from literature and the place of our engineers in the world of innovation is uncovered.

2. Literature Review

In this section related studies from literature will be analyzed. For instance, we analyze the studies of Bulut and Akçacı on [3] Industry 4.0 and the scope of innovation indicators. They expound upon new and basic concepts under Industry 4.0 such as 3D printing, smart factories, the internet of things, and artificial intelligence. Through their paper, researchers study the effect of the geographical placement of Turkey on its competitiveness, production capabilities, and export ratios along with present investments to research and development studies and information technologies. At the end of the study, Bulut and Akçacı conclude that there is a need to increase investment into the internet of things concept along with additional investments into research and development studies in Turkey in order to compete with other countries in innovation race.

The study carried out by Benavente in 2006 focuses on the relationship between innovation and technology in research and development facilities in Chile. With this paper, innovation activities and their effects on productivity are analyzed. During the research, the complete process of innovation is modelled empirically, and related research equations are formed. Two main equations, based on innovation and productivity, are formed

and related correlations are calculated. Outcomes of the paper show that technological opportunities have a great effect on research activities related to innovative ideas in Chile [15].

A study carried out by Sahrom et al. in 2016 focused on the innovative behavior of Malaysian research and development engineers. For this paper [16], researchers gathered data from 218 engineers via a survey application and analyzed the gathered information via structural equation modelling. The researchers supported that the theory that the interaction of engineers with their environment leads to the spreading of knowledge and data, eventually improving creativity and production. With this idea the writers show the importance of individual innovativeness in an engineer. At the end of the study, it was found that the spread of innovative behavior depends on financial investments and gathered knowledge. Thus, it can be interpreted that with the help of technology, industrialization the innovation speed of Malaysia can be upgraded.

Crepon et al. performed their research in 1998 on a firm in France. In this study, researchers formed a model and carried out an inquiry to retrieve data on the innovation knowledge of research and development engineers of a French firm. The paper concluded that the innovativeness of a firm is indicated from its demand pull and technology indicators [17].

In 2016, Vokoun published his study on the process of innovation in the manufacturing industry of the Czech Republic. This paper applied two different sets of surveys to participants and found that the innovative behavior of manufacturing companies in the Czech Republic mainly depended on their size [18]. In other words, big companies tended to support and follow indicators on novelties since they were already members of a business network.

3. Methodology

This paper aimed to examine Turkish engineers' perspectives and perceptions of innovation and Industry 4.0.

To measure such perceptions, a survey was applied to participants from different backgrounds. For gathering data, an inquiry consisting of thirty-four questions was directed to one hundred and twenty engineers from both academic and industial fields. With the help of the first six questions, information such as gender, age, and education was retrieved from the participants and through the remaining twenty-eight questions their perception levels regarding novelty were acquired. The survey used survey was formed of the previously applied survey by Hurt et al. in 1977, arranged in an order that made it suitable for engineers [19]. The original survey is called Individual Innovativeness (II), it is shared via an academic named James McCroskey with the website clearly stating that the questionnaire can be used without any permission for scientific research purposes [20]. Prior to this research, the used survey was translated into Turkish and implemented to Turkish nurses by Ayşegül Sarıoğlu in 2014 [21]. To apply rules of ethics and scientific clarity, related usage permissions were retrieved from both researchers.

The questionnaire was distributed via the internet amongst participants. That is to say, to reach a wide range of engineers the questionnaire was transferred into a survey website and distributed to possible participants with the help of social media. The survey was adapted to create a soft version, with a requirement to answer each question set so that participants could not skip any question. Hence for all participants there were no incomplete or falsely completed forms.

The responses to the questions inside the questionnaire were based on a Likert scale. For instance, when answering an item in the questionnaire the participant was asked to select a choice among five options, namely 5 strongly agree; 4 agree; 3 neither agree nor disagree; 2 disagree; or 1 strongly disagree. Score calculations of the participants were held as stated by Hurt et al. and Sarıoğlu [19,21]. Each participant acquired a label due to their score. The labels called innovators, early adopters, early majority, late majority, and traditionalists were created by Hurt et al. In the whole questionnaire, seventeen of the

items were positive and eleven of them were negative and score calculations of each and every participant was done with the consideration of this separation.

The data from the forms were retrieved from the website with the help of a statistical software named SPSS [22]. Via SPSS 21, the answers of each participant was analyzed and studied and calculations were carried out.

To elaborate, innovators can be defined as the people who seek and adopt change the fastest. People under this category tend to take risks and new steps [23]. Early adopters accept novelty in an early stage. People from early the adopters group guide individuals around them [24]. Participants from the early majority form the majority of society and people from this group are cautious when it comes to taking new actions. They choose to wait and consider the possible outcomes of their actions prior to adapting to any innovation [25,26]. Individuals categorized as the late majority are very shy about innovation. People in this group wait for most of the public to exercise the particular improvement and observe any related outcomes. The last category are the traditionalists and these people are considered to be connected to the past and they are quite isolated [25]. Additionally, traditionalists act with prejudice when they face novelty in their lives [24].

This survey was completed by one hundred and twenty engineers from different backgrounds. In Table 1 the distribution of the participants of this study is given according to their departments.

As can be seen in Table 1, the engineers participated in this study were mostly from the research and development departments of multiple firms, with 44.16% of the total belonging to this group. In terms of the rest of the respondents, 4.16% of the participant engineers belonged to a production department, 5.83% worked in marketing, 4.16% were from purchasing departments, and 41.66% worked in other departments. In this table, the option "other" stands for departments not than listed and also for the academic world.

Table 1. Distribution of participants according to their departments.

Department	Number of Participating Engineers	(%) Percentage
Research & Development	53	44.16
Production	5	4.16
Marketing	7	5.83
Purchasing	5	4.16
Other	50	41.66

4. Findings

The acquired information was studied through SPSS 21 under five different sections. For instance, participants were evaluated according to their gender, age, education level, the department they were employed in, the duration for which they had been actively working, and the industry they worked for. The distribution of the participants of this study according to these demographic questions is presented in the table below. Table 2 presents the distribution of participants according to the gender.

Table 2. Distribution of participants according to their gender.

Gender	Number	(%) Percentage
Female	53	44.16%
Male	67	55.83%

As can be seen from Table 3, a large portion of participants were in the age group of 25 to 30, indicating a group of people who are at the beginning of their work life and from

the Y generation who are entrepreneurial, goal oriented, and most importantly known for their innovative thinking skills [27].

Table 3. Distribution of participants according to their age.

Age	Number	(%) Percentage
25–30	71	59.16%
31–36	33	27.5%
37–42	3	2.5%
43–48	4	3.33%
49–54	7	5.83%
55–60	2	1.66%
61 and above	0	0%

Tables 4–6 present the distribution of parcipants according to industry, education level and length of time actively working, respectively.

Table 4. Distribution of participants according to industry they work for.

Industry	Number	(%) Percentage
Public	16	13.33%
Private	104	86.66%

Table 5. Distribution of participants according to their level of education.

Education	Number	(%) Percentage
Bachelor's Degree	44	36.66%
Master's Student	23	19.16%
Master's Degree	29	24.16%
PhD Student	15	12.5%
PhD Degree	9	7.5%

Table 6. Distribution of participants according to the length of time they had spent actively working.

Length of Time Actively Working (Years)	Number	(%) Percentage
1–5	61	50.83%
6–10	38	31.66%
11–15	7	5.83%
16–20	6	5%
21 and above	8	6.66%

After transferring the acquired data to SPSS, in order to assess the reliability of the study the Cronbach's alpha coefficient was calculated over twenty-eight scaling questions. After these calculations, the initial value of the Cronbach's alpha was determined as 0.75. To interpret this value further, analysis of each and every item on the questionnaire was held and it was concluded that three of the items were not in correlation with the others. After the elimination of these three items, a new reliability test was carried out and a new Cronbach's alpha value was calculated as 0.82. As stated by Goforth (2015), Cronbach's alpha is a measure used to assess the internal consistency of a survey, with an alpha value higher than or equal to 0.8 showing a consistent study [28].

Following the Cronbach's alpha value calculations, the score of each attendee was calculated with the help of software. As presented earlier, the groups and their score intervals were already determined by Hurt et al. through their study in 1977 and those rules were applied to this study as per [19]. After the score calculation of the one hundred

and twenty engineers was completed the engineers were distributed into groups. The obtained situation is presented in Table 7 below.

The score distribution for each group is presented in Table 7, with the engineers who scored the highest in the survey being placed into the innovators group. The placement of each group goes from the highest score to the lowest. Forty-eight of the one hundred and twenty participants fell under the innovators group, this value corresponds to 40% of the whole group. Those in the group with lowest score are described as traditionalists and after calculations it can be seen that there are no traditionalists amongst our study participants. To observe the characteristics of the group, an analysis according to gender, age, and department distributions was also carried out.

Table 7. Scores of participants and their distribution.

Categories	Interval of Score	Participants	
		Number	Percentage
Innovators	Above 82	48	40%
Early Adopters	Between 75–82	47	39.16%
Early Majority	Between 66–74	18	15%
Late Majority	Between 58–65	7	5.83%
Traditionalists	57 and above	0	0%

With the help of Table 8 it can be observed that number of male participants is higher than female participants. As seen in Table 8, the ratio of innovators in male attendees is higher than in female attendees.

Table 8. Analysis according to gender.

Categories	Female		Male	
	Number	Percentage	Number	Percentage
Innovators	19	36%	29	43%
Early Adopters	21	40%	26	39%
Early Majority	8	15%	10	15%
Late Majority	5	9%	2	3%
Traditionalists	0	0%	0	0%

As presented in Table 9a,b, the participants were distributed over several age intervals. Unfortunately, the survey could not reach any engineers who were 61 years old or older.

Table 9. Analysis according to age.

(a)						
Categories	25–30		31–36		37–42	
	Number	Percentage	Number	Percentage	Number	Percentage
Innovators	32	45%	10	30%	1	33%
Early Adopters	24	34%	17	52%	0	0%
Early Majority	10	14%	5	15%	2	67%
Late Majority	5	7%	1	3%	0	0%
Traditionalists	0	0%	0	0%	0	0%
(b)						
Categories	43–48		49–54		55–60	
	Number	Percentage	Number	Percentage	Number	Percentage
Innovators	2	50%	4	57%	1	50%
Early Adopters	0	0%	3	43%	1	50%

Early Majority	1	25%	0	0%	0	0%
Late Majority	1	25%	0	0%	0	0%
Traditionalists	0	0%	0	0%	0	0%

Analysis made by departments is presented in Table 10.

Table 10. Analysis according to the department.

(a)						
Categories	Research and Development		Production		Marketing	
	Number	Percentage	Number	Percentage	Number	Percentage
Innovators	26	49%	0	0%	4	57%
Early Adopters	16	30%	4	80%	2	29%
Early Majority	8	15%	1	20%	1	14%
Late Majority	3	6%	0	0%	0	0%
Traditionalists	0	0%	0	0%	0	0%
(b)						
Categories	Purchasing		Other			
	Number	Percentage	Number	Percentage		
Innovators	2	40%	16	32%		
Early Adopters	3	60%	22	44%		
Early Majority	0	0%	8	16%		
Late Majority	0	0%	4	8%		
Traditionalists	0	0%	0	0%		

Participants were expected to select the suitable answer for themselves regarding the question of which department they belonged to, whether it be research and development, production, marketing, purchasing and other choices. The "other" option stands for departments other than those listed and also for the academic world. According to the findings, the most innovative department amongst the selection was the research and development department. This is an important outcome, since unlike the other departments members of research and development departments should recognize especially dynamism and use sources to foster innovative behaviors [16].

5. Conclusions and Discussion

This study aimed at finding the notions of Turkish engineers towards novelty and innovation-related concepts such as Industry 4.0 and big data. Most of the researchers in this area focus on finding this answer through the relation of engineers with incentive opportunities, regulations, and patent numbers. On the other hand, in this study we targeted measuring the levels of innovative behavior and self-innovativeness. Prior to going over the outcomes of this study a comparison of other papers from the literature will be undertaken. For instance, in their study in 2016 Sahrom et al. measured innovative behavior among diversified research and development engineers in Malaysia. There were Chinese, Malaysian, and Indian engineers in their participant groups [16]. The writers conducted their study through applying questionnaires to attendees. The results of this study state that the application and adopting of innovation requires financial support and a wide range of know-how.

In 2006, Benavente researched the effect of innovation and productivity in Chile [15]. To conduct this study Benavente selected Chilean research and development engineers and collected data through a survey. For this study, the researcher formed a hypothesis and related equations. After necessary calculations, Benavente says that openness to research and desire for improvement increased gradually with the size of the company in which the engineers work. Thus, from this situation we can interpret that technological opportunities effect research actions and the growth of innovative ideas.

In their study in 2007, de Jong and Hartog analyzed the role of leaders and managers on the innovative behavior of engineers who work under them. This paper states that engineering is important for innovation and improvement since novelty includes the application of ideas. For the data collection of this study, the researchers conducted face to face interviews and talked to attendees about concepts such as ideal leadership, vision, rewarding ideology, and so on. At the end of the study it was found that for a company to be innovative, its employees have to be keen on innovation. This result also fits to the aim and starting point of this paper since for a country to be innovative, its companies and engineers should be open to new ideas and the application of new technologies [11].

In 1998, Crépon et al. studied the innovation and productivity levels of engineers in a French firm. In their research, the writers formed a model along with productivity and innovation equations. In this study the gathering of data was done through the use of a survey. In the results of the study it was shown that the innovative behavior of the firm's employees increased with the implementation of new technology [17]. Thus, from this paper it can be said that technology and innovation concepts are two notions that cannot survive without one another. In order to supply power to the innovation process, technological improvements such as Industry 4.0 should be followed closely.

Bulut and Akçacı performed a study on Industry 4.0 and innovation indicators in Turkey in 2017. In their paper the researchers summarized concepts about Industry 4.0, innovation, and other related topics [3]. Writers presented that the geopolitical placement of Turkey is very important in terms of exportation and low-cost production opportunities. It is stated that in order to increase its chances in terms of international competitiveness, Turkey should follow innovative ideas. In the case of innovation, the application of Industry 4.0 is supported as inevitable. The importance of research and development for Turkey's improvement is stated and the importance of high technology implementations is given. The paper concludes that there is a need for increased investment in areas related to the internet of things along with research and development activities.

For finding the perceptions of Turkish engineers toward innovation and Industry 4.0, a survey with total of thirty-four questions was directed to attendees from different backgrounds. The first six questions aimed to gather information about the participant's socio-economic situation, also known as demographical information, and the remaining twenty-eight questions targeted the perception of engineers on novelty. Through the analysis of the surveys it was found that engineers who attended to this research were at a good level in terms of innovation and self-innovativeness, since the ratio of innovators among the group is quite high and there is not any traditionalists among them. To be clear, it can be said that the ratio of innovators among the participant is 40%. Thus it can be interpreted that engineers in Turkey are open to innovation and applications related to Industry 4.0 are familiar to them.

From this study, it is seen that novelty related concepts such as big data, artificial intelligence, and smart factories are widespread topics. Participants of this study are well informed about importance of following improvements and innovations. It is important to state that keeping this know-how at its present state and increasing it in the future is a crucial entity for Turkish technology, with one possible solution to this target being the teaching of entrepreneurship to engineers as a compulsory course during their bachelor's degree. Another solution could be the provision of opportunities to engineering students enabling them to create a project based on innovation, innovation management, or innovation engineering during their selective courses in order to help them gain a basic level of knowledge on these concepts as well.

For future studies, as previously discussed, focusing solely on research and development engineers should be an aim. Moreover, transferring this study to engineering students is an ongoing study performed by the writers of this paper. The outcomes of this research will be contributed to the literature soon.

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