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AWARENESS ANALYSIS OF INDUSTRY 4.0 *

ENDÜSTRİ 4.0'IN FARKINDALIK ANALİZİ

Kevser YILMAZ[1], Aşkın ÖZDAĞOĞLU[2]

1. Arş. Gör., Dokuz Eylül Üniversitesi, kevser.yilmaz@deu.edu.tr, https://orcid.org/0000-0003-0415-8844
2. Doç. Dr., Dokuz Eylül Üniversitesi, askin.ozdagoglu@deu.edu.tr, https://orcid.org/0000-0001-5299-0622

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Abstract

Industry 4.0 is a new disruptive (r)evolution that not only affects the production systems of companies but also affects the society as a whole. This new revolution brings several new benefits to firms, such as; a more flexible production system, individual production, digital value chain, new business models, resource, and energy efficiency. Therefore, it is very important for firms to be aware of the Industry 4.0. In this study, the Industry 4.0 awareness of the firms located in İzmir and Manisa is investigated. Moreover, a chi-square analysis is conducted in order to determine the relationship between firm size and awareness of Industry 4.0's terms and R&D budget of firms and awareness of Industry 4.0's terms.

Keywords: *Industry 4.0, Awareness Analysis, Cyber-Physical Systems, Internet of Things, Big Data*

Öz

Endüstri 4.0, sadece şirketlerin üretim sistemlerini değil, aynı zamanda toplumu bir bütün olarak etkileyen yeni yıkıcı bir (d)evrimdir. Bu yeni devrim, firmalara; daha esnek bir üretim sistemi, bireysel üretim, dijital değer zinciri, yeni iş modelleri, kaynak ve enerji verimliliği gibi birçok yeni avantajlar getirmektedir. Dolayısıyla, firmaların Endüstri 4.0'ın farkında olmaları önemlidir. Bu çalışmada İzmir ve Manisa'da yer alan firmaların Endüstri 4.0 farkındalığı araştırılmıştır. Ayrıca, firma büyüklüğü ile Endüstri 4.0 terimlerinin bilinirliği ve şirketlerin araştırma ve geliştirme bütçelerinin olması ile Endüstri 4.0 terimlerinin bilinirliği arasında bir ilişki olup olmadığı bulmak için ki-kare analizi kullanılmıştır.

Anahtar Kelimeler: *Endüstri 4.0, Farkındalık Analizi, Siber Fiziksel Sistemler, Nesnelerin İnterneti, Büyük Veri*

GENİŞLETİLMİŞ ÖZET

İlk sanayi devrimi, yeni makinelerin icadı ve buhar gücünün üretimde kullanılması ile 18. yüzyılın sonunda Büyük Britanya'da başladı. 20. Yüzyılı gelindiğinde ise, elektrik, üretimin sistemlerinde kullanılmaya başlandı ve bu da ikinci sanayi devriminin tetikleyici oldu. Üçüncü sanayi devrimi, dijital teknolojilerin gelişimi ile 1970'lerin başında başladı. Dördüncü ve son sanayi devrimi ise 2011 yılında Alman hükümeti tarafından Hannover Fuarı'nda tanıtıldı. Endüstri 4.0 olarak da bilinen dördüncü sanayi devrimininim ana teknolojik gelişmeleri olarak siber-fiziksel sistemler, otonom robotlar, yatay ve dikey sistem entegrasyonu, simülasyon, nesnelerin interneti, siber güvenlik, bulut sistemleri, katmanlı üretim, büyük veri ve arttırılmış gerçeklik olarak açıklanabilir. Endüstri 4.0 ile birlikte ürün ve hizmetlerin geliştirilmesinde yeni sistemler kullanılmaya başlanacak, bu da üretimin daha esnek ve çevik olmasını sağlamakla kalmayıp, daha verimli, etkin ve kişiye özel ürün üretilebilmesini sağlayacaktır. Ayrıca, bu sanayi devrimi ile beraber, sadece üretim sistemleri değil, toplum ve çalışanlarda, iş gücünden istenilen yetkinliklerin değişmesi ve yeni teknolojilerin kullanılması ile müşteri analizlerinin daha detaylı yapılması ile etkileneceklerdir. Bu nedenlerden dolayı, hem rekabet üstünlüğü elde etmek hem de değişen koşullara uyum sağlayarak hayatta kalmak için firmalar dördüncü sanayi devrimine önem vermektedir.

Bu çalışmanın amacı İzmir ve Manisa illerinde bulunan firmaların Endüstri 4.0 terimleri hakkında farkındalıklarını tespit etmektir. Ayrıca, çalışmada, Endüstri 4.0 terimlerinin bilinirliği ile firma büyüklüğü ve Ar-Ge bütçesi arasında bir ilişki olup olmadığı araştırılmıştır. Dördüncü sanayi devrimi firmaların yapısını etkilediğinden, anket genel yöneticilere dağıtılmıştır. Analiz birimi firma seviyesidir.

Veriler, ek bölümünde yer alan anket yoluyla toplanmıştır. Anket hazırlandıktan sonra, anket soruları araştırmanın içerik geçerliliğini artırmak için üç aşamadan geçmektedir. İlk olarak, anadili İngilizce olan bir araştırmacı IDC raporundan çevrilen soruları incelemiştir. Gerekli düzenlemeler yapıldıktan sonra, 10 akademisyen anketin anlaşılabilirliğini test etmek için sorularını okumuş ve değerlendirmiştir. Gerekli değişiklik yapıldıktan sonra, ankette gereksiz bir soru olup olmadığını öğrenmek için iki üretim müdürü ile yüz yüze görüştüler gerçekleştirilmiş ve anket son şeklini almıştır.

Bu çalışmada kolayda örneklem yöntemi kullanılmıştır. Anket soruları Aliağa Organize Sanayi Bölgesi, Buca Ege Giyim Organize Sanayi Bölgesi, Atatürk ve Manisa Organize Sanayi Bölgesi, İzmir ve Ege Serbest Ticaret Bölgelerinde bulunan firmalara e-posta yoluyla gönderilmiştir. Bu organize bölgeler ve serbest ticaret bölgeleri kolay erişilebilirlik nedeniyle seçilmiştir. Veri toplama sürecinin sonunda yalnız 13 firma anketi cevaplamış, yetersiz örneklem büyüklüğü nedeniyle araştırmacılar veri toplamak için ayrıca kartopu örnekleme yöntemine başvurmuştur. Böylece, katılımcı şirketlerden anketi diğer şirketlere göndermeleri istenmiştir. Bu sayede, çalışmada kullanılan 25 veri kartopu örnekleme yöntemleri elde edilmiş ve bu çalışmanın örneklem büyüklüğü 38 olmuştur.

Bu makalenin veri analizi iki aşamadan oluşmaktadır. İlk bölümde, katılımcıların ve firmaların demografik özelliklerini değerlendirmek için betimsel analizler yapılmıştır. İkinci bölümde, anket yoluyla toplanan veriler SPSS 24 sürümü kullanılarak analiz edilmiştir. Hipotez testi aşamasında, parametrik olmayan testlerden biri olan ki-kare testi, endüstri 4.0 ile ilgili terimlerin farkındalığı ile firma büyüklüğü ve Ar-Ge bütçeleri arasında bir ilişki olup olmadığını araştırmak için kullanılmıştır.

Yapılan betimsel analize göre, Endüstri 4.0 terimi (% 23,36) firmalar tarafından en çok bilinen terimdir. Nesnelerin interneti (% 17,52), fabrika düzeni (% 16,06) ve büyük veri (% 16,06) firmalar tarafından en çok bilinen diğer terimlerdir.

Ayrıca ki-kare analizlerine göre, büyük firmaların KOBİ'lere kıyasla büyük veri, toplum 5.0 ve nesnelerin interneti terimlerinin daha farkında oldukları sonucuna varılmıştır. Dahası, firmaların Ar-Ge bütçesinin varlığı ile Endüstri 4.0'ın terimlerinin farkındalığı arasında bir ilişki olup olmadığını öğrenmek için başka bir ki-kare analizi yapılmıştır. Analiz sonucu, Ar-Ge bütçesine sahip firmaların, Ar-Ge bütçesine sahip olmayan firmalara kıyasla, büyük veri ve nesnelerin internet terimlerinin farkında olduklarını göstermektedir.

Diğer taraftan, bu çalışmanın gelecekteki araştırmalar için fırsatlar yaratan bazı sınırlamaları vardır. Bu araştırmanın en önemli kısıtlılığı kullanılan örnekleme yöntemidir. Kolayda ve kartopu örneklemesi yöntemi çalışmasın genellenebilirliğini kısıtlamıştır. Ayrıca, veriler İzmir ve Manisa şehirlerinden toplanmıştır. Bu nedenlerden dolayı, yeni araştırmacılar farklı örnekleme yöntemlerini kullanarak ve farklı coğrafi alanlarda faaliyet gösteren firmalara ulaşarak, firmaların Endüstri 4.0 hakkındaki farkındalığını tekrar test edebilirler. Bu çalışmanın üçüncü sınırlaması ise firma sektörü ile ilgilidir. Bu çalışmada, çeşitli sektörlerden veri toplandığından dolayı, sektörler arasında bir örüntü ve terimlerin farkındalığı analizi yapılamamıştır. Böylece, gelecekteki çalışmalar belirli bir sektöre/sektörlere odaklanarak sektörlerin Endüstri 4.0 ile ilgili terimlerin farkındalığı ile sektörün Endüstri 4.0'dan beklentileri, görüşleri ve zorlukları hakkında araştırmalar yapabilir.

1. INTRODUCTION

The first industrial revolution began by the end of the 18th century in the Great Britain, due to invention of new machines and usage of steam power in production. Industry 1.0 affected production systems, subsequently reshaping the whole society. Afterward, usage of electricity in a butchery factory triggered the second industrial revolution.

New inventions and technological developments triggered the third industrial revolution. Information technology and automation were used more frequently in production. This revolution also is called the "Green Revolution", because individuals had started to see the effects of the using high amount of fossil fuels on the environment. Sustainability became the main focus of businesses, governments and the whole world. Furthermore, high-speed railroad systems, fiber optic, satellite, cellular phones, inventions of the internet, 3D printer technology, and biogenetic research were the important breakthroughs in this era.

In the 21st Century, the new industrial revolution, which is referred to as Industry 4.0, began. Industry 4.0 changes all manufacturing systems and brings new technologies and systems to production such as, internet of things, cyber-physical systems, big data. Within this new era; production systems, machines and all goods will have small microchips that will transform them into “smart goods” that humans can control remotely. Additionally, most systems will be managed by robots. Automation in the factories will increase dramatically. Products will be tailored specifically for the individual. Moreover, jobs and business descriptions and competition dynamics are the other areas that will be affected from the fourth industrial revolution.

In the first part of this article, industrial revolutions will be briefly introduced. Following this, Industry 4.0 and the nine pillars will be defined. Under the awareness application, we will measure the firms Industry 4.0 awareness through firm size. Moreover, additional information about firms’ research and development (R&D) budget, sector, Industry 4.0 stages, and challenges of Industry 4.0 and benefits of various information technology (IT) integration will be provided.

2. INDUSTRIAL REVOLUTIONS

With the end of the 18th century, the first industrial revolution began through the inventions of machines and the usage of steam power. Mechanization is the core characteristic of the Industry 1.0 (Kagermann et al., 2013). Thus, as the fabric of production systems changed, small work areas returned to factories (Drath and Horch, 2014, p. 1). Production become quicker and cheaper than before due to new inventions and machines (Allen, 2006, p. 29; Jensen, 1993, p. 834).

In the 20th Century, usage of electricity in the production initiated the second industrial revolution (Atkeson and Patrick, 2001, p. 3; Kagermann et al.,2013; Rosenberg,1998, p. 8). Mass production became possible with the usage of new energy in factories.

The third industrial revolution begun in the early 1970s. In 1969, automation systems became digitally programmable by humans through invention of programmable logic controller. Thus, more flexible and efficient production were possible (Kagermann et al., 2013). Automation and information technology were the core elements of this industrial revolution (Blanchet et al., 2014, p. 7; Jazdi, 2014, p. 1).

Industry 4.0 firstly introduced in 2011 at Hannover Fair by the German government (Kagermann et al., 2011). In 2013 German National Academy of Science and Engineering (acatech) declared paper about Industry 4.0 (Kagermann et al., 2013). However, different countries and companies have accepted Industry 4.0 philosophy with a different name, for example, Germany mostly uses “Industrie 4.0”, English- speaking countries and European Union prefer the name of Internet of Things (IoT) (Kagermann et al., 2013). China has developed a strategic plan named “Made in China 2025” in order to catch up technologic developments of Industry 4.0 (Liu, 2016), Japanese carried the term one step forward and uses the term, “Society 5.0”. This

term is a joint integration of countries technological developments and society's values (Wang et al, 2016a). Finally, General Electric uses the term "Industrial Internet" (Evans and Annunziata, 2012).

3. NINE FUNDAMENTAL TECHNOLOGIES OF INDUSTRY 4.0

Kagermann et al. (2013) define Industry 4.0 as the collection of smart factories, cyber-physical systems (CPS), self-organization, new systems in distribution and procurement, new systems in the development of products and services, adaptation to human needs and corporate social responsibility. Moreover, according to Blanchet et al., (2014, p. 7-9) cyber-physical systems and marketplace, smart robots and machines, big data, a new quality of connectivity, energy efficiency and decentralization, virtual industrialization and factory 4.0 are key characteristics of Industry 4.0. Furthermore, Boston Consulting Group (BCG) published a report about the essential technologies of the Industry 4.0, which are autonomous robots, simulation, horizontal and vertical system integration, industrial internet of thing, cyber-security, the cloud, additive manufacturing, augmented reality and big data and analytic (Rüßmann et al., 2015). Thus, cyber-physical systems, smart factory, cyber-security, vertical & horizontal integration system, autonomous system, internet of things (IoT), big data, augmented reality and cloud system are the core technologies of Industry 4.0, which are explained in the following paragraphs.

Rajkumar et al. (2010, p.731) define cyber-physical systems as "physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core". Cyber-physical systems can be basically defined as a bridge that form a connection between the real and virtual world while using internet of things technologies (Kagermann et al., 2013) and computing and communication infrastructures (Baheti and Gill, 2011, p. 161; Rajkumar et al., 2010, p. 731; Schmidt et al., 2015, p. 17).

The second core technology of the Industry 4.0 is smart factory that brings a new approach to production (Kagermann et al., 2013, p. 7). The smart factory is defined as the implementation of cyber-physical systems inside a factory (Wang et al 2016b, p. 7; Wang et al., 2016c, p.159). In a smart factory; employees, machines, sources, and systems use the cyber-physical systems to communicate with each other, also this technology provides a suitable environment to share information (Kagermann, 2015, p. 33). Thus, the aim of smart factory technology is to satisfy customers better by a quicker response to customers' needs and wants (Zhou et al., 2015; Shrouf et al., 2014, p. 698). Flexible and agile production (Wang et al., 2016c, p. 159) and solving problems and helping managers and employees in real-time without stopping production are some features of this technology (Lucke et al., 2008, p. 1).

Cyber-attacks can be performed either by using the availability and connectivity of the systems or by using security vulnerabilities (Xie et al., 2010, p. 213). Moreover, cyber-attack not only induce damage of factories or production system but also company's reputation, image and abilities to controlling processes are affected negatively (Byres and Lowe, 2004, p. 4). The above highlights why cyber-security is an important technology; Industry 4.0's technologies, firms' machines and systems use internet to communicate each other and share information, these open network systems may face cyber- security threats more often (Byres and Lowe, 2004, p. 1; Rüßmann, et al., 2015, p. 4). So that without cyber-security, valuable knowledge of firms will be in danger of cyber-attacks.

The other core technology of Industry 4.0 is vertical & horizontal integration system. Basically, these integration functions can be explained as horizontal integration and provides intercorporate cooperation with using value network, vertical integration forms hierarchical subsystems inside firms which ensures elastic and reconfigurable manufacturing system (Wang et al., 2016b, p. 2).

Robots already have been employed in the factory (Rüßmann et al., 2015, p. 3), however, their capabilities, skills and functions are very restricted. With Industry 4.0, new technologies contribute towards the development of autonomous systems. Thus, these systems become more flexible, cooperative and self-configuring (Blanchet et al., 2014, p. 8; Kagermann et al., 2013; Rüßmann et al., 2015, p. 3). Moreover, they

can take decision themselves with using their sensors without receiving approval from a human, to justify their actions (Redfield and Seto, 2017, p. 103), and give response to the different situations (Kagermann et al., 2013, p. 20).

Internet of things technology will play central roles in the revolution of Industry 4.0, because, with this technology, objects have special identities which bring new abilities, such as; connecting to the internet, storing all data, sharing information to and receiving information from the other objects in real time (Kagermann, 2015, p. 25).

The other fundamental technology of Industry 4.0 is big data. Big data can be defined as a large-volume (Blanchet et al., 2014, p. 8), complicated, heterogeneous and unstructured data. (Chen et al., 2014, p. 171; Wu et al., 2014, p. 97). Data can be obtained from multiple sources automatically (Rüßmann et al., 2015, p. 2-3; Wu et al., 2014, p. 97), it is not controlled by any central and does not depend on any control mechanism (Wu et al., 2014, p. 98). Big data supports the managers when making decisions in real time (Rüßmann et al., 2015, p. 2-3).

Virtual and augmented reality terms can be thought as a similar word, but these two terms have different in some perspective. For example, virtual reality (VR) provides a synthetic platform for users with adding real objects to the virtual platform consequently the virtual has been enhanced. However, users cannot see the real world when using it (Azuma, 1997, p. 355; Kerawalla et al., 2006, p. 164; Liu et al., 2007). On the other hand, augmented reality (AR) enhances the real word (Liu et al., 2007) and improve users experience through creating a bond between the virtual and real world (Azuma et al., 2001, p. 34; Klopfer and Squire, 2008; Van Krevelen and Poelman, 2010, p. 1; Paelke, 2014, p. 1). Augmented reality makes easier lives of employees because they directly reach information about the new tasks such as which parts should be selected, the location of parts and repair instruction (Rüßmann et al., 2015, p. 5). So that firms can more quickly adapt to their production system to the dynamic environment (Paelke, 2014, p. 1). Furthermore, herewith this technology, before a built a new plant or launching a new product, all possibilities will be simulated in virtually, hereby firms will earn time and decrease their cost (Blanchet et al., 2014, p. 9).

National Institute of Standard and Technologies (NIST) define cloud technology as a "Cloud computing model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grance, 2011). To sum up, cloud systems can be defined as a platform; users can easily reach, manage and reconfigure resources (Vaquero et al, 2008, p. 51) within minutes or seconds. That system provides some technological, economical and timesaving benefits to firms (Rüßmann et al., 2015). Whole collected and produced data can be available from both everywhere and everyone (Botta et al., 2016), also cost of holding data decreases thanks to cloud system (Kagermann, 2015, p. 26). When all benefits of the nine fundamental technologies of Industry 4.0 are met, understanding and applying the Industry 4.0 concepts become essential for firms.

4. APPLICATION

4.1. Objectives

The main objectives of the study are to identify awareness of firms located in İzmir and Manisa cities about Industry 4.0's terms and to find out whether there is a relationship between firm size and awareness of Industry 4.0's terms and R&D budget of firms and awareness of Industry 4.0's terms.

4.2. Methodology

Data is collected using structured questionnaires, which is available in the Appendix section. The survey is distributed to general managers, as the fourth industrial revolution affects the structure of firms.

Thus, it is argued that the general manager is aware of the fourth industrial revolution and the firms' approach. The unit of analysis is the firm level.

The questionnaire that is used for this study consists of four parts. The first part contains questions about the descriptive features of both respondents and firms. In the second part of survey, there is only one statement that aims to clarify which terms are known by firms. Third and fourth parts of the questions (between 12-27) are taken by International Data Corporation (IDC) Report (Schulte, 2016).

After the questionnaire is prepared, survey questions pass three stages to increase the content validity of the research. Firstly, a native speaker evaluated the questions, which are taken from IDC report and based on her feedback, translation error was corrected. After that, 10 academicians read and evaluated the survey questions to prevent ambiguity problems on the survey. After required amendment is made, researchers made face to face interviewed with two production managers to learn whether there is an unnecessary question on survey, and as to their evaluations, the survey was modified and take its final shape.

Sample size of this study is 38. The sample of the study is determined by non-probabilistic methods. The survey contains questions about specific information of firms and their strategies about Industry 4.0. So that survey questions should be answered by the general managers, however, some of the surveys are answered by other white-color personnel. Difficulties in reaching general managers, time and budget constraints are the main reasons to select the convenience sampling method. In this study convenience and snowball sampling methods are used together to determine the sample.

The first stage of this study employed use of the convenience sampling method was used. Survey questions were distributed to firms located at Aliağa, Buca Ege Sanayicileri, Atatürk and Manisa organized industrial zone, İzmir and Ege free-trade zones. These organized zones and the free-trade zones were selected due to easy accessibility. E-mail information of firms were reached through the internet web site of industrial zones and free-trade zones and the survey was distributed. General information about survey such as the purpose of the study, who can answer the questions, information protection policy etc. were written in the e-mails, the survey was attached to e-mails and 600 e-mails were sent to firms on 17.12.2017.

4 firms were located at the Atatürk organized zone, 5 firms were located at the Gaziemir free-trade zone and 4 firms were located at the Manisa organized industrial zone answered the survey. So that, 13 firms are answered survey questions through e-mail.

Thereafter, snowball sampling method had determined to used by the researchers due to insufficient sample size. Thus, the respondent companies were asked to send the survey to other companies. So that, the remaining part of the sample (25 firms) are obtained snowball sampling methods and end of the study, the sample size was 38 and survey collection period was between December to May, 2018 for this study.

Data analysis of this article can be collected under two parts. In the first part, descriptive analyses are made to evaluate demographic characteristics of the respondents and firms. In the second part, data collected through survey are analyzed using SPSS 24 version. In the hypotheses testing phase, one of the nonparametric tests is chi-square which is used to find out whether there is a relation between firm size and awareness of the terms related to industry 4.0. Chi-square test is used when data are nominal and the aim of the study is to learn whether there is a relation between two variables or not (McHugh, 2013, p. 143; Rencher, 2003).

4.3. Hypotheses

Industry 4.0, Made in China 2025, society 5.0, cyber-physical systems, big data, advanced manufacturing partnership, internet of things and factory layout terms are selected as the dependent variables of the hypotheses because; Industry 4.0 term has been used as define the fourth industrial revolution in 2011 by Germany government (Kagermann et al., 2011), Made in China 2025 is the Chinese version of the fourth industrial revolution (Liu, 2016), society 5.0 that is adaptation society to the changes of Industry 4.0 has been

used by the Japanese (Wang et al., 2016) and the cyber-physical systems used as a synonym of Industry 4.0 (Vogel-Heuser and Hess, 2016). So that these terms are the synonymous name of the Industry 4.0. Moreover, some terms are effected technologies/areas by Industry 4.0 such as; big data and internet of things technology are the result of the new industrial revolution (Kagermann et al., 2013), advanced manufacturing partnership had been launched by Obama in U.S. (Secretary, 2011), that is a kind of partnership consist of the industries, universities and the federal government to invest in emerging technologies like as Industry 4.0. (Johnson, 2016), vertical and horizontal integration and smart factories concept will change the design of factory, manufacturing systems. So that, factory layout is one of the most affected areas from the fourth industrial revolution (Wang et al., 2016).

When the literature is examined, it is found that a firm's capacity and innovation level are connected to each other. Introduction of new products, new processes, or new marketing or organizational methods are related innovation activities and large firms can obtain more benefit in those fields when compared with the SME's (Golgeci and Ponomarov, 2015; Hult et al., 2004). Because large firms have a greater technological ability, can allocate more cash flow and assets for innovation (Rogers, 2004) and make more R&D activities due to their financial abilities (Kortuem, 2010; Scherer, 1991). Moreover, a research that is made in the European manufacturing industry in 2008 reveals that product and process innovation performances of large firms are better than the small and medium-sized enterprises (Vaona and Pianta, 2008). When all factors that are mentioned above are evaluated, it is revealed that large firms can easier follow innovation and technological changes thanks to their financial abilities and R&D budget than SME's. Thereby, large firms can more aware of the Industry 4.0's terms than SME.

Firm size is divided into four categories according to employees' numbers. These categorizations are formed according to Türkiye Cumhuriyeti Küçük ve Orta Ölçekli İşletmeleri Geliştirme ve Destekleme İdaresi Başkanlığı (Kosgeb) categorization (Kosgeb, 2018). If firms have 0-9 employees they are named as micro small and medium enterprises (SME), 10-49 employees as small scaled SMEs, 50-249 employees as medium scaled SMEs, 250 or above employees as large-scale firms. There are three different small and medium enterprises categories, so that, to reach more properly firm size distributions, micro, small-scaled and medium-scaled enterprises are categorized as SME category. So that, firm size categories are decreased from 4 to 2 which are SME and large firms. After that, hypotheses are constructed to reveal whether there is a relationship between firm size and awareness of Industry 4.0's terms. The hypotheses constructed are as follows:

H1: There is an association between the firm size and awareness of "Industry 4.0".

H2: There is an association between the firm size and awareness of "Made in China 2025".

H3: There is an association between the firm size and awareness of "Big Data".

H4: There is an association between the firm size and awareness of "Society 5.0".

H5: There is an association between the firm size and awareness of "Advanced Manufacturing Partnership".

H6: There is an association between the firm size and awareness of "Internet of Things".

H7: There is an association between the firm size and awareness of "Factory Layout".

H8: There is an association between the firm size and awareness of "Cyber-Physical Systems".

Moreover, Industry 4.0 brings some new opportunities to firms such as all products, goods and systems will be smart, and they can collect data by using sensors and share them with other devices, goods and managers with the internet of things technology. At that time, cyber-physical systems will become a part of the production activity and create a connection between the virtual and real world (Kagermann et al., 2013; Bahati and Gill, 2011, p. 161; Rajkumar et al., 2010, p. 731; Schmidt et al., 2015, p. 17). However, this causes some technical problems, which should be solved by firms. For examples, reliable and foreseeable

software programs should be developed in order to create a connection between virtual and real world, also proper software programs and algorithms should be purchased by companies to select accurate data from a large pool and categorize, analyze and interpret them. Moreover, organizational structure and technological infrastructure of firms should be ready to implement to Industry 4.0 in their firms. Thereby, research and development budget of firms are crucial to buy or develop software programs, make essential changes both managerial department and technological infrastructure of firms. Thereby, there is a question in the survey to learn whether they have R&D budget or not. When the firms have R&D budget, which is coded yes, otherwise is coded no. 14 firms did not answer that question. Next, hypotheses are constructed to reveal whether there is a relationship between existence of R&D budget of firms and awareness of Industry 4.0's terms. The hypotheses constructed are as follows:

H9: There is an association between the existence of R&D budget of firms and awareness of "Industry 4.0".

H10: There is an association between the existence of R&D budget of firms and awareness of "Made in China 2025".

H11: There is an association between the existence of R&D budget of firms and awareness of "Big Data".

H12: There is an association between the existence of R&D budget of firms and awareness of "Society 5.0".

H13: There is an association between the existence of R&D budget of firms and awareness of "Advanced Manufacturing Partnership".

H14: There is an association between the existence of R&D budget of firms and awareness of "Internet of Things".

H15: There is an association between the existence of R&D budget of firms and awareness of "Factory Layout".

H16: There is an association between the existence of R&D budget of firms and awareness of "Cyber-Physical Systems".

4.4. Descriptive Analysis

Table 1 gives information about the gender and age distribution of the sample. Male respondents are approximately four times more than women.

Table 1. Gender and Age Distribution of the Sample

		Age				**Total**
		26-34	**35-44**	**45-54**	**55 and more**	
Gender	**Female**	3	4	1	0	8
	Male	15	8	5	2	30
Total		18	12	6	2	38

Work experience and career of the respondents are shown in the Table 2. From the information provided under the Table, it is seen that most of the respondents' career is engineer or manager.

Table 2. Work Experience and Career Distribution of the Sample

		Career				
		N/A	**Engineer**	**Manager**	**Market Research Specialist**	**Total**
Work Experience	**0-4**	0	8	0	1	9
	5-9	0	6	4	0	10
	10-14	0	4	3	0	7
	15-19	1	2	2	0	5
	20-24	1	3	0	0	4
	25 and more	1	0	2	0	3
Total		3	23	11	1	38

In the survey, firm size is divided into four categories. These categorizations are formed based on Kosgeb website (Kosgeb, 2018). The sample size is 38 and 20 of them (52,63%) are large firms, 1 of them (2,63%) is micro SME, 7 of them (18,42%) are small-scaled SMEs, and lastly, 10 of them (26,32%) are medium scaled SMEs. Firm size is categorized into two parts in order to reach more achieve an effective respondent distribution. After categories are decreased from 4 to 2, there are 20 large firms and 18 SMEs.

Table 3 gives information about firm categorization and Research and Development (R&D) budget of firms. 14 of firms (36,84%) intentionally leave the question blank, which is coded as N/A, 8 of firms (21,05%) have no R&D budget, remaining firms have an R&D budget.

Table 3. Firm Categorization and R&D Budget of Firm

		R&D Budget					
		N/A	**0 TL**	**15.000-100.000 TL**	**100.001-999.999 TL**	**1 Million and more**	**Total**
Firm Categorization	**SME's**	4	7	4	2	1	18
	Large Firms	10	1	0	2	7	20
Total		14	8	4	4	8	38

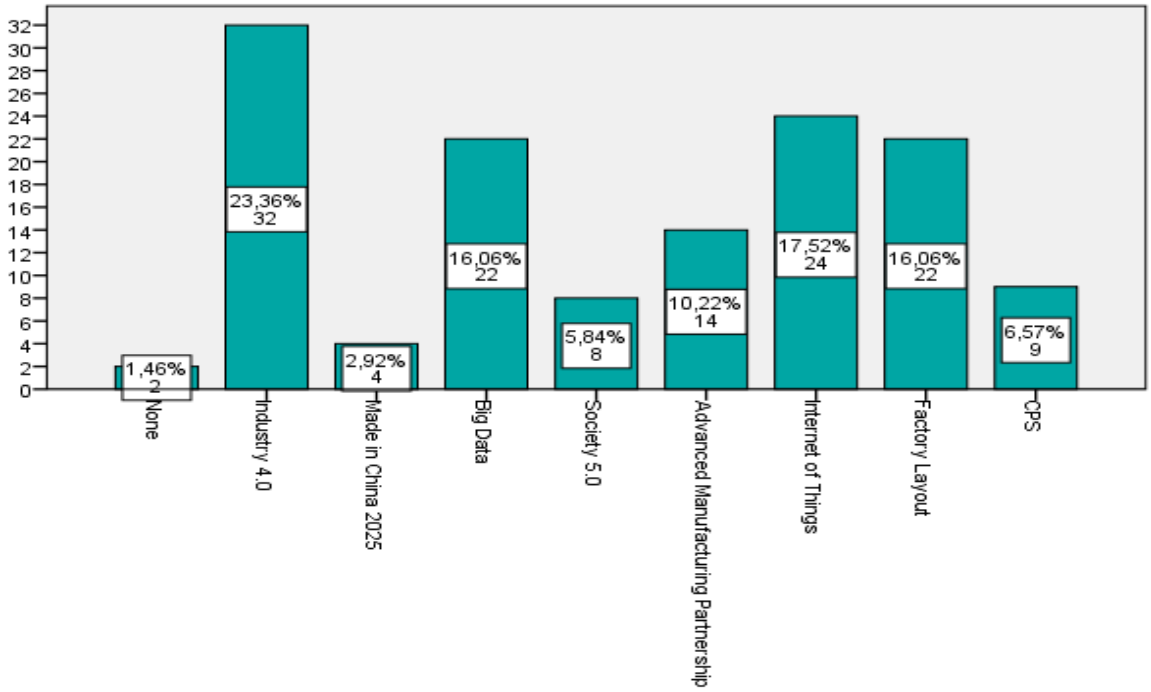
In the survey, each firm wrote its sector as text, after that, sectors of companies were categorized based on "Kamuyu Aydınlatma Platformu" (KAP) sector categorization information (KAP, 2018). The sector of firms based on the firm size can be seen in Table 4.

Table 4. Sector of Firms based on Firm Categorization

		Sector of Firm								Total
		Manufacturing	**Sales and Marketing**	**Metal goods, machine and equipment production**	**Transportation**	**Electricity, gas and water**	**Whosaler, retailer trade**	**Mine**	**Financial institutions**	
Firm Categorization	**SME's**	10	3	1	2	1	0	1	0	18
	Large Firms	13	1	2	0	2	1	0	1	20
Total		23	4	3	2	3	1	1	1	38

Moreover, survey contains question to learn which Industry 4.0 terms are known by the firms. Each firm select one or more terms that they are aware. Figure 1 shows which terms mostly known by firms. To sum up, Industry 4.0, internet of things, big data and factory layout terms are the most known terms by firms.

Figure 1. Industry 4.0 terms are known by the Firms



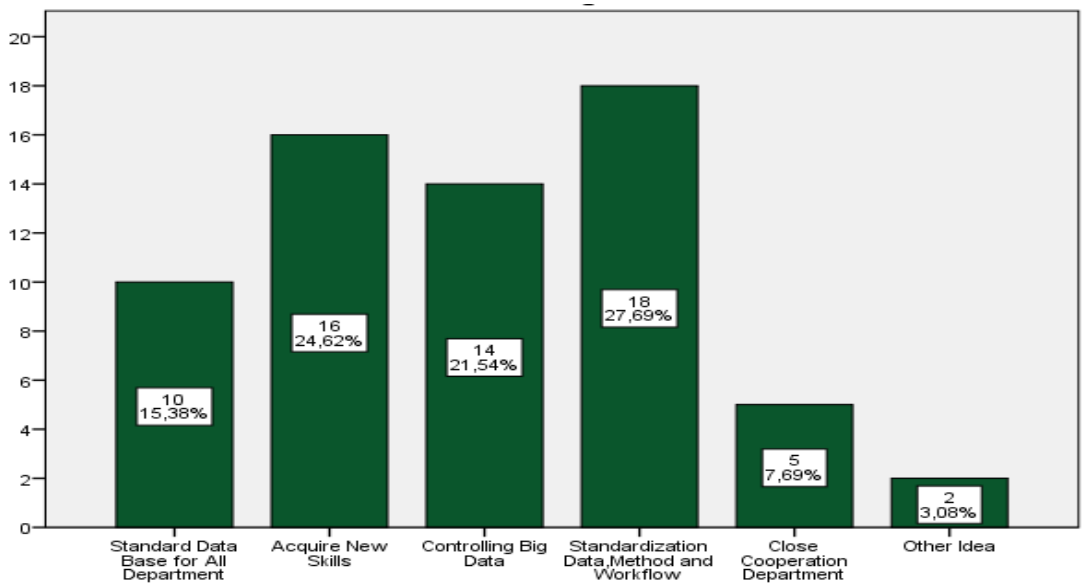
Furthermore, there is a question in the survey to learn firms are in which stage of Industry 4.0 application. Table 5 shows how many SME's and large firms are in the evaluation, planning or application phases.

Table 5. Industry 4.0 Stage of Firms

		Industry 4.0 Stage						
		No Evaluation/Application	**Evaluation**	**Planning**	**Pilot Application**	**Limited Application**	**Compehensive Application**	**Total**
Firm Categorization	**SME's**	9	6	2	0	1	0	18
	Large Firms	3	9	2	3	1	2	20
Total		12	15	4	0	2	2	38

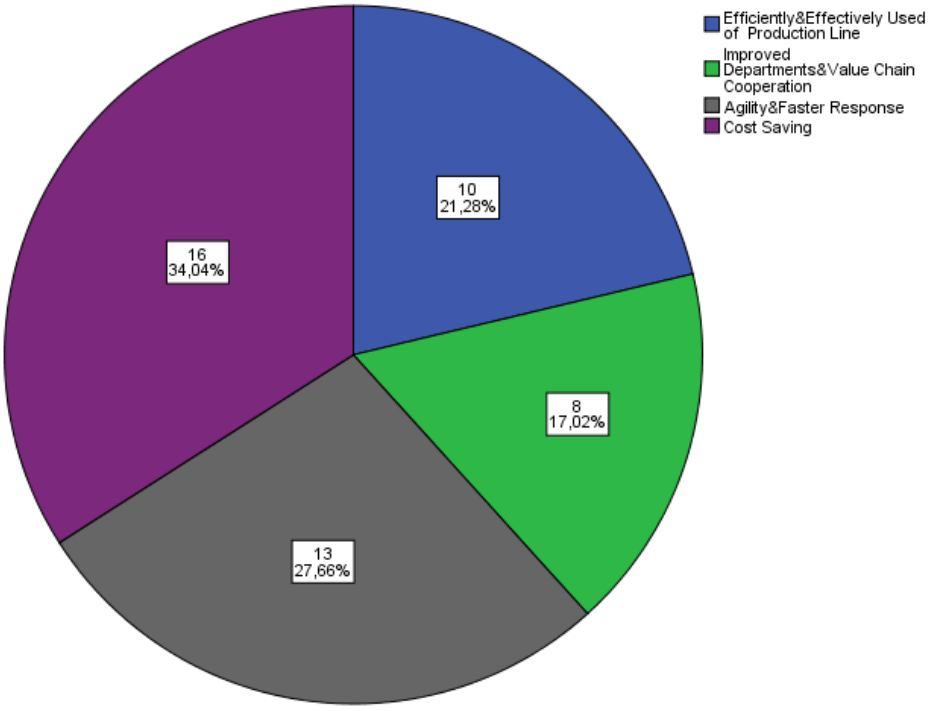
New technology application always is a difficult period for companies. Firms face challenges during technology application stage and aim of fifteen question in the survey to get information from firms about what kind of challenges firms should deal with during Industry 4.0 application phases. Figure 2 gives information us about main challenges. According to answers, standardization data, method, and workflow and acquiring new skills are the most important challenges, which companies can deal with during Industry 4.0 application.

Figure 2. Main Challenges of the Industry 4.0



In addition, following question ask firms their expectations about the benefits of various IT integration when to apply Industry 4.0 in companies. Firms can pick more than one answers but they can choose maximum 2 answers because prevention randomly chose. Figure 3 shows benefits of different information technology integration. Therefore, it can be concluded that cost saving, and agility and faster response are benefits demanded more by firms.

Figure 3. Benefits of Various IT Integration



4.5. Hypotheses Testing and Results

In this section, sixteen different hypotheses are analyzed, and the results reveal the relations between two categorical variables due to using Chi-square method.

Firm size and awareness of the Industry 4.0 term is as shown in Table 6. 3 SME's and 2 large firms do not know the Industry 4.0, 15 SME's and 18 large firms know the term.

Table 6. Firm Size and Awareness of Industry 4.0 Term

			Industry 4.0		
			No	**Yes**	**Total**
Firm Size	**Small-Medium Enterprises**	**Count**	3	15	18
		Expected Count	2,4	15,6	18,0
	Large Firms	**Count**	2	18	20
		Expected Count	2,6	17,4	20,0
Total		**Count**	5	33	38
		Expected Count	5,0	33,0	38,0

In line with this information, the following hypotheses have been developed;

H0: There is no association between the firm size and awareness of "Industry 4.0".

H1: There is an association between the firm size and awareness of "Industry 4.0".

Table 7. Chi-Square Test Results of Industry 4.0 Term and Firm Size

	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	.368a	1	.544		
Continuity Correctionb	.016	1	.899		
Likelihood Ratio	.369	1	.543		
Fisher's Exact Test				.653	.448
Linear-by-Linear Association	.359	1	.549		
N of Valid Cases	38				
a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.37.					
b. Computed only for a 2x2 table					

Table 8. Symmetric Measures of Industry 4.0 and Firm Size

		Value	**Approximate Significance**
Nominal by Nominal	**Phi**	.098	.544
	Cramer's V	.098	.544
N of Valid Cases		38	

From chi-square test, data do not meet the chi-square assumption of all expected frequency, 2 cells have expected less than 5, that are "no" part of the SME's and large firms are shown in Table 7. However, Fisher's Exact Test is an alternative to chi-square when data do not meet assumptions of expected frequency (Fisher, 1925). $\chi 2(1, N=38) = .653$ (Table 7), $p>0.05$, $\Phi=0.098$ (Table 8), $p>0.05$. So that, the exact significance (2-sided) value is 0.653 which is bigger than 0.05. Therefore, the H0 hypothesis is not rejected and there is no association between the firm size and awareness of Industry 4.0.

Table 9. Firm Size and Awareness of Industry 4.0 Terms Hypotheses Evaluation

Firm Size and Awareness of Terms	**H_0**	**Chi-Value**	**Phi Value**
Industry 4.0	Not Rejected	0.653	0.098
Made in China 2025	Not Rejected	1.000	-0.018
Big Data	Rejected	0.000	0.579
Society 5.0	Rejected	0.045	0.361
Advanced Manufacturing Partnership	Not Rejected	0.428	0.129
Internet of Things	Rejected	0.010	0.420
Factory Layout	Not Rejected	0.552	0.096
CPS	Not Rejected	0.130	0.281

The other hypotheses are tested by chi-square method and rejected and not rejected hypotheses are available in Table 9. As a result, there is not a relation between firm size and awareness of Industry 4.0, made in China 2025, advanced manufacturing partnership and factory layout terms. Whereas, there is a relationship between firm size and big data, society 5.0 and internet of things. Large firms are more aware of those these terms than SMEs.

In addition, other chi-square tests are conducted to test relationship between existence of R&D budget of firms and awareness of Industry 4.0 terms. Table 10 shows that firms which have and have not R&D budget and show awareness of Industry 4.0 terms. Based on the results, 14 firms have R&D budget and know Industry 4.0 term, on the other hand 5 firms have not R&D budget and know Industry 4.0 term. To learn whether there is any relation between existence of R&D budget and awareness of Industry 4.0 term, chi-square test is conducted and the results are shown in the Table 11 and Table 12.

Table 10. Existence of R&D Budget and Awareness of Industry 4.0 Term

			Industry 4.0		
			No	**Yes**	**Total**
Is there any R&D Budget?	**Yes**	**Count**	2	14	16
		Expected Count	3.3	12.7	16.0
	No	**Count**	3	5	8
		Expected Count	1.7	6.3	8.0
Total		**Count**	5	19	24
		Expected Count	5.0	19.0	24.0

In line with this information, the following hypotheses have been developed;

H0: There is no association between the existence of R&D budget of firms and awareness of "Industry 4.0".

H9: There is an association between the existence of R&D budget of firms and awareness of "Industry 4.0".

Table 11. Chi-Square Test Results of Industry 4.0 Term and Existence of R&D Budget

	Value	**df**	**Asymptotic Significance (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	2.021a	1	.155		
Continuity Correction	.789	1	.374		
Likelihood Ratio	1.922	1	.166		
Fisher's Exact Test				.289	.186
Linear-by-Linear Association	1.937	1	.164		
N of Valid Cases	24				
a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.67.					
b. Computed only for a 2x2 table					

Table 12. Symmetric Measures of Industry 4.0 and Existence of R&D Budget

		Value	**Approximate Significance**
Nominal by Nominal	**Phi**	-.290	.155
	Cramer's V	.290	.155
N of Valid Cases		24	

From chi-square test, data do not meet the chi-square assumption of all expected frequency, 2 cells have expected less than 5, that are "no" part of the SME's and large firms are shown in Table 11. However, Fisher's Exact Test is an alternative to chi-square when data do not meet assumptions of expected frequency (Fisher, 1925). $\chi 2(1, N=24) = .289$ (Table 11) , $p>0.05$, $\Phi=-0.290$ (Table 12), $p>0.05$. So that, the exact significance (2-sided) value is 0.289 which is bigger than 0.05. Therefore, the H0 hypothesis is not rejected and there is no association between the existence of R&D budget of firms and awareness of "Industry 4.0".

Table 13. Existence of R&D Budget of Firms and Awareness of Industry 4.0 Terms Hypotheses Evaluation

Existence R&D Budget and Awareness of Terms	**H_0**	**Chi-Value**	**Phi Value**
Industry 4.0	Not Rejected	0.289	-0.290
Made in China 2025	Not Rejected	1.000	0.107
Big Data	Rejected	0.027	-0.530
Society 5.0	Not Rejected	0.526	-0.267
Advanced Manufacturing Partnership	Not Rejected	0.352	-0.259
Internet of Things	Rejected	0.032	-0.478
Factory Layout	Not Rejected	0.390	-0.237
CPS	Not Rejected	0.526	-0.267

The other hypotheses are tested by chi-square method and rejected and not rejected hypotheses are available in Table 13. As a result, there is not a relation between existence R&D budget and awareness of Industry 4.0, made in China 2025, society 5.0, advanced manufacturing partnership, factory layout and cyber-physical system terms. Whereas, there is a relationship between existence R&D budget and big data, and internet of things.

5. CONCLUSION

The Fourth industrial revolution officially began in 2011 at the Hannover Fair. Internet technologies and digitalization are the primary power behind the Industry 4.0. This revolution has not only caused changes in production systems but also the markets, competition dynamism and jobs duties has affected from it.

Production systems have a new perspective with this revolution. More flexible, autonomous, smart and robotics production in factories has become possible and almost all production has been made by robots. Moreover, the autonomous system and robots can control, manage and change the production systems when necessary and make decisions with using the data without receiving any orders from managers. Additionally, they can learn new things from the environment and gain new abilities. In addition, factories can be controlled by managers remotely.Quickly changed production process and the smart connection have induced the unique and completely individualized production.

Consequently, massive changes will wait for the firms, employees and whole society that explains the motivation of this study. In this article, information is collected from firms to locate in İzmir and Manisa cities in order to evaluate the awareness of them about Industry 4.0's terms. According to the analysis, Industry 4.0 term (23,36%) is the most known term by the firms. Internet of things (17,52%), factory layout (16,06%), and big data (16,06%) are the others mostly known terms by firms.

Moreover, one of the non-parametric method, chi-square is used to find out whether there is a relationship between firm size and awareness of Industry 4.0's terms. Based on the results, it is concluded that large firms are more aware of the big data, society 5.0 and internet of things terms when compare to SME's. Furthermore, another chi-square analysis is made to learn whether there is a relationship between existence of R&D budget of firms and awareness of Industry 4.0's terms. Result of the analysis show that when the firms have R&D budget, they are more aware of the big data and internet of things terms than others.

On the other hand, this study has some limitations, which create opportunities for future research. The most important limitation of this research is the sampling method that is used. Convenience and snowball sampling are non-probabilistic sampling technique which results in a generalizability issue of the findings. Moreover, data are collected from in İzmir and Manisa cities of Turkey. So that, new researchers can use different sampling method and reach firms operated to different geographic areas, extending the sample size to test awareness of the firms about Industry 4.0. The third limitation relates to the sector of firms. In this study, data is collected from various sectors, so there is not to draw a pattern between sectors and awareness of the terms. Thus, future studies can focus on a specific sector/s and collect data about expectations, opinions, challenges of firms that when decide to apply the Industry 4.0.

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Appendix: Survey Questionnaire

Sayın Katılımcı,

Endüstri 4.0'ın farkındalık analizi amacıyla yapılan bu ankete katılmanız, araştırmada doğru bilgiler elde etme bakımından son derece önemlidir. Elde edilecek bilgiler, GİZLİ tutulacak olup; sadece bilimsel amaçlarla kullanılacaktır. Talep etmeniz durumunda hazırlanacak makale sizlere de gönderilecektir. İşbirliğiniz ve katkılarınız için teşekkür eder, saygılar sunarız.

1. Cinsiyetiniz: ( ) Kadın ( ) Erkek
2. Yaşınız: ( ) 18-25 ( ) 26-34 ( ) 35-44 ( ) 45-54 ( ) 55 ve üzeri
3. Eğitim durumunuz: ( ) İlköğretim ( ) Lise ( ) Üniversite ( ) Yüksek Lisans ( ) Doktora
4. Mesleğiniz: _____
5. İş deneyiminiz: ( ) 0-4 yıl ( ) 5-9 yıl ( ) 10-14 yıl ( ) 15-19 yıl ( ) 20-24 yıl ( ) 25 yıl ve üzeri
6. Mezun olduğunuz fakülte hangisidir?

( ) İktisadi ve İdari Bilimler Fakültesi ( ) Edebiyat Fakültesi ( ) İletişim Fakültesi
( ) Mühendislik Mimarlık Fakültesi ( ) Açıköğretim Fakültesi ( )Diğer:_____
( ) Güzel Sanatlar Fakültesi ( ) Hukuk Fakültesi

7. Şirketin Çalışan Sayısı: ( ) 0-9 ( ) 10-49 ( ) 50-249 ( ) 250 ve üstü
8. Firmanızın Ar-Ge bütçesini belirtiniz: _____
9. Firmanız hangi sektör ve alanda faaliyet göstermektedir? _____
10. Firmanız kaç yıldır faaliyet göstermektedir? _____
11. Aşağıdaki kavramlardan hangilerini duydunuz? Duymuş olduğunuz kavramları lütfen işaretleyiniz.

( ) Endüstri 4.0-Industry 4.0-Industrie 4.0 ( ) Advanced Manufacturing Partnership- İleri Üretim Ortaklığı
( ) Made in China 2025 ( ) Internet of Things, Nesnelerin İnterneti
( ) Big Data- Büyük Veri ( ) Factory Layout -İş Yeri Düzenlenmesi ( ) Hiçbiri
( ) Society 5.0-Toplum 5.0 ( ) Cyber-Physical Production Systems-Siber-Fiziksel Üretim Sistemleri

12. Endüstri 4.0 terimini nereden duydunuz ?

( ) İş yeri dışında duzenlenen seminer/ konferans
( ) İş yerinde düzenlenen eğitim/bilgilendirme toplantıları/seminer/konferans
( ) Televizyon ( ) Sosyal medya ( ) Gazete/Dergi ( ) Diğer (belirtiniz)_____

13. Şirketiniz endüstri 4.0 uygulamasında hangi aşamadadır?

( ) Herhangi bir değerlendirme ve uygulama yok (bu seçeneği işaretleyenler için anketimiz sonlanmıştır, teşekkürler.)
( ) Değerlendirme ( ) Sınırlı uygulama
( ) Planlama ( ) Kapsamlı uygulama
( ) Pilot uygulama ( ) Diğer (belirtiniz)_____

14. Aşağıdaki uygulamalardan hangisi, şirketinizde planlanan veya uygulanan Endüstri 4.0 girişimlerini tanımlıyor ve/veya hangileri Endüstri 4.0'ın entegrasyonu için uygundur? (Birden çok seçenek işaretleyebilirsiniz.)

( ) Üretim ağı içi işlemlerin izlenmesi ve optimizasyonu ( ) Ürün testleri ve kalite güvencesi
( ) Makine ve tesisin uzaktan izlenmesi ( ) Envanterin planlanması
( ) Kurum içi makine ve sistemlere bakım, temizleme, tadilat ( ) Üretim akışlarının simülasyonu
( ) Sipariş hazırlığı sonrasında ürünlerin üretim modüllerinin düzenlenmesi ( ) Hiçbiri

15. Endüstri 4.0'ı gerçek hayatta kullanmaya başladığınızda sizin bakış açınıza göre karşılaşmayı beklediğiniz zorluklar nelerdir ve/veya endüstri 4.0 nedeniyle var olabilecek mühendislik sorunları ne olabilir? (En fazla 3 şık işaretleyiniz.)

( )Tüm departmanlar için standart bir veri tabanının geliştirilmesi
( ) Gerekli yeni beceri ve yeterliliklerin kazanılması
( ) Artan veri hacimlerinin, çeşitliliğinin ve karmaşıklığının kontrol altına alınması
( ) Veri, yöntem ve iş akışlarının standardize edilmesinin gerekliliği
( ) Şirket içi departmanlar arasında daha yakın işbirliğinin gerekliliği
( ) Diğer(belirtiniz)_____

16. Kurumunuzda çeşitli bilgi sistemlerinin (IT) entegrasyonundan hangi faydaları bekliyorsunuz? (En fazla 2 şık işaretleyiniz.)

( ) Geliştirilmiş üretim kullanımı (üretim hattının daha etkin ve verimli kullanımı)
( ) Bölümler arası ve/veya değer yaratmadaki işbirliğinin daha iyi olması ( ) Maliyet tasarrufu
( ) Daha yüksek çeviklik / yeni gereksinimlere daha hızlı tepki verilebilmesi ( ) Diğer_____

17. Büyüyen veri (big data) ile tüm verilere tam zamanında ve doğru şekilde ulaşım artacak ancak bu beraberinde güvenlik sorunları getirecek. (Bilgilerin bulut (cloud) programlar üzerinden paylaşılması ve bu bilgilere daha kolay ulaşım nedeniyle bilgi hırsızlığı gibi) Bilgi ve veri güvenliğini sağlayabilmek için kullandığınız/kullanmayı planladığınız programlar var mı? ( ) Evet ( ) Hayır

(Tablonun devamı sonraki sayfada)

18. Geçen yıllarda şirketinizde çalışanlardan kaynaklanmayan ne tür bir güvenlik (bilgi güvenliği, siber saldırı vb.) oldu? (Gerekirse 2 taneye kadar seçim yapabilirsiniz.)
( ) Üretim manipülasyonu ( ) Kişisel yaralanma (işçilerin yaralanması)
( ) Üretim duruşu ( ) Hiç bir şey olmadı
( ) Fikri mülkiyetin çalınması ( ) Diğer:_____
( ) Kurumsal kaynak yazılımı vb. ile ilgili problemler
19. Şirketinizde Endüstri 4.0 için ayrılmış bir bütçe var mı? ( ) Evet ( ) Hayır
20. Önümüzdeki yılda Endüstri 4.0 planları ve/veya uygulamaları için bir bütçe olacak mı? ( ) Evet ( ) Hayır
21. Kosgeb'in endüstri 4.0 için hibe/destek planı sayesinde yatırımlarınızı arttırmayı planlıyor musunuz? ( )Evet ( )Hayır
22. Sizi bu ve bunun gibi destekler teşvik ediyor mu? ( ) Evet ( ) Hayır
23. Endüstri 4.0'ı hayata geçirmenin üç ana zorluğu nedir?
24. Endüstri 4.0'ın katma değer üretebileceği işletme alan ve/veya alanlarınızı tanımlayınız.
25. Endüstri 4.0 sayesinde ürünlere, üretim hattına, sistemlere ve belgelere dijital erişilebilirlik ve aynı zamanda ürün, üretim hattı, sistem ve belgeler arasında eş zamanlı olarak bilgi akışı ve değişimi olacaktır. Bu sistem hayata geçtiğinde üretim bölümü olarak en çok hangi problemlerden kurtulmuş olacaksınız?
26. Endüstri 4.0 sayesinde montaj hattına mobil cihazlar ile 3-boyutlu olarak ulaşım sağlanabilecektir. (akıllı gözlükler, arttırılmış gerçeklikler vb.) Bu size ne gibi avantajlar sağlar?
27. Hangi tür yenilik, robot ya da otomasyon sizin işlerinizi hızlandırır ve kolaylaştırırdı? Endüstri 4.0'ın getirdiği teknolojik yenilikleri düşündüğünüzde hangi teknolojilerin işletmenizde kullanılmasını isterdiniz?