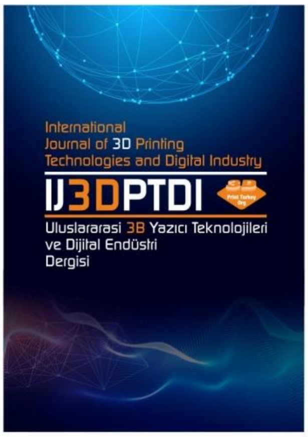

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THE EFFECTS OF R&D-DESIGN CENTERS ON INDUSTRY 4.0

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THE EFFECTS OF R&D-DESIGN CENTERS ON INDUSTRY 4.0

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ABSTRACT

Globalization has accelerated the transition from labor intensive production models to knowledge/ technology intensive production models. Research & Development (R&D) and Design activities increase productivity and profitability for the company at micro level and contributed to the increase in the needed transformation at macro level. Products and services progressed in R&D and Design Centers improve effectively to both the industry and our country. R&D and Design activities cannot be limited to certain disciplines. Digitalization of sensors, actuators, workbenches and instruments used in manufacturing can be achieved by people in design and R&D Centers. There is a need for a high-profile awareness study of what Industry 4.0 is and its contributions. Bringing together technology companies, firms and academics working in industry 4.0 components will be positive in terms of creating mutual learning. The collection of big data during the processes allows us to achieve more accurate results about the production helping to avoid the situations like stopping the production or preventing to producing of faulty products. For example, users in the automobile or parts supply industries have the measurement data of the cylinder head. They can store many data together with working material, production process and conditions. All the data affecting the cylinder head is collected in a single database. Therefore, the integration of software and customers into the production systems are becoming increasingly important.

Keywords: Industry 4.0. R&D Centers. Design. Digitalization.

1. INTRODUCTION

Water and steam powered mechanization (Industry 1.0), electric energy powered mass production (Industry 2.0) and automation, semi-conductor technology (Industry 3.0), and all three are considered as an individual precedent Industrial Revolutions each of which lasted for couple of decades. Industry 4.0 (I4.0), the fourth industrial revolution which first emerged in Germany in 2011 during a trade fair, is now influencing the whole world and has gained prominent place for numerous research center, university and company along the last three years. I4.0 optimizes computerization of Industry 3.0 revolution. Figure 1 illustrates evolution from Industry 1.0 to Industry 4.0. Common targets of industry revolutions are zero-mistake, more solid, reliable processes, and lower cost.

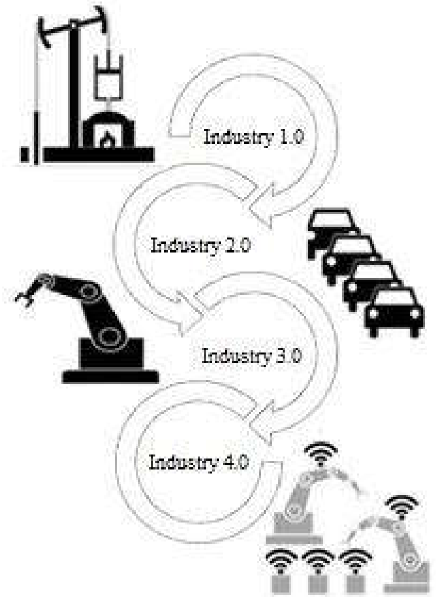


Figure 1. Historical evolution of industry revolutions.

Modern industrial development has continued couple of centuries and now it is period of Industry 4.0. Targets of Industry 4.0 are higher operational productivity and efficiency and higher automation level. Since researches on Industry 4.0 have dynamic characteristic, a comprehensive literature search is necessary to obtain systematic and extensive analysis of the last researches on Industry 4.0. Within the scope of the present study, a comprehensive research was conducted on Industry 4.0, R&D, and Design Centers; and a general view on scope and practices of Industry 4.0 was tried to be exhibited. All available literature contained by the Web of Science and Google Academic data bases was screened (Figure 2).

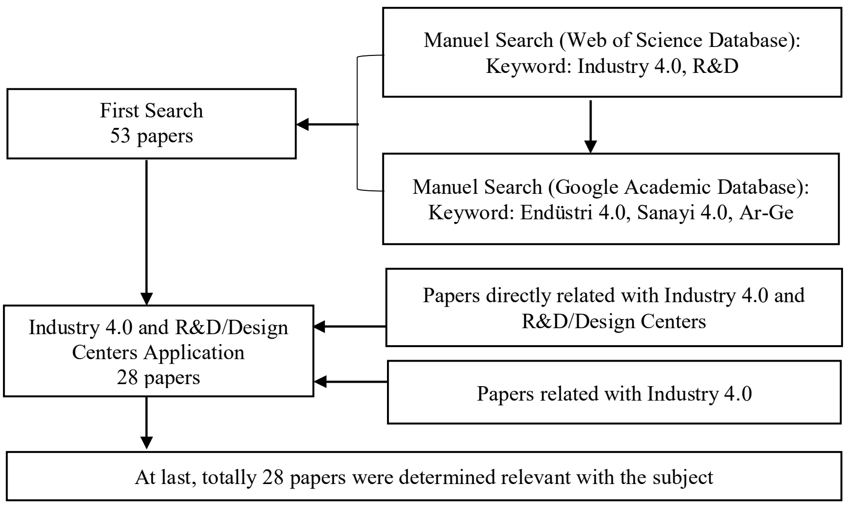


Figure 2. Procedure for determining relevant literature.

Industry 4.0 has attracted attention of researchers and academic journals along the recent years. It has been seen that whereas frontier engineering and computer sciences journals have brought Industry 4.0 to prominence, academics from social sciences have not been interested in this subject yet. Resources such as internet of things, cyber-physical system, large data, data analytics, and intelligent factories have been used more frequently by authors in their articles which were screened in our study. In an evaluation made based on the links specified by researchers in their articles, the extensive scope of the interest exhibited by Germany, the country introduce Industry 4.0 concept to the world, could be realized from the relevant articles. On the other hand, in our Turkey, there is no satisfactory literature that has been flourished yet.

After 5 years from the Germany's introduction of Industry 4.0 to the world, this new concept has become widely known by all over the world; and in the meantime it was transferred from its original practice area in industrial manufacturing to other engineering and non-engineering domains. Industry 4.0 concept is not limited directly by the manufacturing takes place in company. Additionally, it includes a complete value chain comprised of suppliers, clients, all commercial functions and services of business. “Industry 4.0 Study Group” and “Industry 4.0 Platform” work environments which bring academics and practitioners together are fundamental supporters of Industry 4.0 idea [1-2]. Since the time when Industry 4.0 was first announced as high technology strategy in Germany in 2011, numbers of academic articles have been concentrated on this subject [3-6]. The reference of “Industry 4.0” has become widely known upon suggestion of by the union of business, politics, and faculty represents in 2011 to strengthen German manufacturing industry’s competitive power [7]. Based on the studies in the recent literature, Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS) and Intelligent Factory were considered as four essential constituents of Industry 4.0 [8].

Cyber-Physical Systems (CPS) consisted of combination of physical and virtual world; and it is one of the elemental components of Industry 4.0 [9]. Radio Frequency Identification (RFID) technology makes identification for a living creature or an object through a microchip connected to an antenna [10]. The second generation CPS is equipped with sensors and actuators with limited number of function. The third generation CPS is equipped with multiple sensors and actuators capable of data storage and analysis.

Internet of Things and Services describes intelligent objects and products equipped with sensors. IoT is a general term used for intelligent things. These products interact together and integrated over internet. In the meantime, they are utilized in the medical products, agriculture industry, and special consumer products [11]. IoT enables all system and sub-system components, processes, human users to interact and communicate and to perform intelligent measurements.

CPS constitutes intelligent factories future’s manufacturing environments triggered by the advancement of manufacturing systems. In intelligent factories, machines undertake responsibilities of humans. For integration of employees with digital, electronic and virtual world, processes are required to be at the highest possible level in terms of reliability, productivity and security. Accordingly, new facilities (virtual factory) are required to be designed by considering new parameters or criterions; and current updates are required to be completed [12].

Industry 4.0 interconnects physical and digital processes for intelligent manufacturing capable of evaluating and describing for higher level systems owing to their increasing needs for data collection, processing and data storage. "Industry 4.0 Revolution" plans to integrate artificial intelligence, internet of things, artificial neural networks, cloud technologies and similar things to organization world and manufacturing processes. The objective of the fourth industrial revolution is a manufacturing model in which human and non-human things are communicated with each other through internet or local networks. Entrepreneurs are required to be ready for updating their practices and to get ready all potential development by taking these developments into consideration. They need to learn these concepts; necessary updates are required to be completed in terms of both individually and organizationally.

In order to ensure Turkey’s success in this process in parallel with the developed countries, the consciousness about the Industry 4.0 need to be enhanced. In this regard, project incentive mechanisms need to be established; government supports to be increased; computer programming systems, intelligent sensors, mobile applications and mobile end-user devices need to be developed besides infrastructures such as network and hardware. Strategy documents prepared across Turkey reveals notable aspects. However, application process for enhancing determined aspects is significantly important together with efficiency of these practices. Adjusting to the Industry 4.0 process could only be possible with long-term investments. Therefore, necessary legal, financial and technical regulations need to be completed for long-term investments and especially R&D-based risky investments.

At the first place, Turkey needs to complete development of automation and computer sciences systems process which constitute foundation of Industry 4.0. Yet, medium and high levels of technological manufacturing have low level of share in value added currently. Moreover, share of the trade is also greater than the industry. This situation results in disadvantage of Turkey in terms of its harmonization with Industry 4.0 progress. Therefore, high technology manufacturing needs to be prioritized. Although western countries are in effort to retract these investments from developing countries, in the computer programming dimension, developing countries would still take part in the transformation progress to the some extent. Especially computer programming does not require certain place or work shift. Consequently, skilled human labor in developing countries could participate in this progress. In this regard, computer sciences and communication industries will be the future's industries.

Industry 4.0 will evolve potential and way of employment of blue-collars in workplaces equipped with robots and automation. Therefore, with the proliferation of Industry 4.0, while some old professions disappear leave their places to new ones. When it is considered in terms of human resources, since computer programming is the most essential constituent of Industry 4.0, employers competent in coding and algorithm developers would come to prominence. Accordingly, Industry 4.0 would eventually trigger Education 4.0. An education system needs to be prepared starting from primary school, continue with the whole education life; and then would take a shape of life-long learning. Within its curriculum, individuals' analytic thinking and coding skills are required to be developed as well as data analysis and design talents along the education phases.

In the Turkish Computer Programming Industry Strategy and Action Plan published by the R.T. Ministry of Industry and Technology, computer sciences developments in computer programming-based technologies such as advancing artificial intelligence, robotic technologies, intelligent manufacturing systems, 3-D printers, internet of things, large data and cloud companied with Industry 4.0 were emphasized; and it was remarked that the countries that could conform to these developments would higher global competitive strength. Conforming to the National Wideband Strategy and Action Plan (2017-2020), in the digital transformation roadmap, the essential priorities were enhancing internet access speeds and to lower associated cost especially in the planned industry zones. On the other hand, the required environment is tried to be provided for digital transformation by implementing standardization studies and legislative works for data storage and analysis needs that arise along the manufacturing phases. In addition, activities are planned to be conducted to develop and usage of cloud infrastructure in Turkey safely.

In parallel with digitalization, it is assumed that especially muscle-powered operations will be transferred to robots across the manufacturing industry; humans will be employed for the positions requiring qualification and skill. In manufacturing processes, since labor force is assumed to be emphasized at the development, design, programming and optimization of technologies requiring intellectual qualification rather than muscle power, it is important to develop qualifications of current labor force and to ensure new generation labor force to acquire talents and competence necessary to be employed in these domains. In this regard, quality of technical and vocational education need to be increased; new programs need to be developed at universities for digital technologies so that labor force could be educated to fulfill necessities of digital age. In order to raise awareness levels of businesses, state of art examples are required to be described and these practices need to be expanded as well as developing cooperation among stakeholders.

2. TECHNOCITIES, R&D AND DESIGN CENTERS

Three elemental industrial revolutions have pass through in the world history. During the first industrial revolution in the 18th century, steam power and mechanization emerged while the second industrial revolution introduced mass production in the 19th century. Furthermore, humanity transited into automation in the 20th century; electronic and information technologies came into our daily lives. Industry 4.0 is a digitalization concept including all phases/ operations/processes from purchase of raw materials, to manufacturing products, their transport to consumers, and all steps in supply chain as well as numerous modern automation systems, data exchange and manufacturing technologies in which wide variety an vast amount of data is stored, monitored and analyzed to yield efficient work models.

2.1. R&D and Technocities

Increasing welfare and development levels of countries could be possible through R&D, innovation and design. Enhancing quality and standards of goods manufactured in a country, ensuring participation of technological knowledge, incenting innovative efforts with the manufactured products/manufacturing processes, ensuring increasing productivity, reducing manufacturing costs, accelerating commercialization of technological knowledge, allowing cooperation among businesses before competition, accelerating foreign investments to enter in technology-intense manufacturing, entrepreneurship and R&D / Design, supporting employment of R&D / Design personnel and qualified labor are included in the scope of the Law with 5746 serial number [13].

By the OECD Frascati Guidebook, R&D is described as "systematic studies conducted systematically to enhance human, culture and social knowledge". R&D includes fundamental research, applied research and empirical development activities. In the Oslo Guide, OECD described innovation as application of a "new or significantly improved; as a product (goods or service), or as a process; a new marketing method; or a new organizational method in work practice, workplace organization, or external area". Innovation is a development adding value in every aspect. Innovation is not only considers "products", but also innovation in other domains such as "service", "process" and "marketing".

According to the 4th Article of the Law Regarding Incentives to Research, Development and Design Activities with 5746 Serial number: "R&D center refers units founded to maintain order-based R&D and innovation projects or contract frameworks by tax payer organizations, workplaces, capitalized companies in Turkey and separately formed within body of a corporation and solely operates in Turkey on research and development activities, and which employ minimum fifty full time R&D personnel, and which have adequate R&D competency and professionalism" [13].

According to the 4th Article of the Law Regarding Incentives to Research, Development and Design Activities with 5746 Serial number, "Design center refers units with adequate design experience and competency to carry out design projects or contractual framework depends on order. These units could be operated by tax payer organizations in Turkey; or capitalized company's individual department organized as a separate unit located in Turkey; for design activities and employs minimum ten fulltime design personnel [13].

According to the Law Regarding Incentives to Research, Development and Design Activities with 5746 Serial number concerning support of Research, Development and Design Activities, there is not notable difference between incentives designated for R&D centers and design centers. Both facilities are subject to the same regulations. While R&D discount is assumed for R&D Centers, similar discount exists for Design Centers. In addition, government incentives such as income tax cut effective on decreasing personel cost, SGK employer share discount, duty tax exemption, and custom tax exemptions are provided for both R&D and Centers. The single essential difference between two centers is the science support. While grant support is made available for the R&D personnel graduated from departments of fundamental sciences, there is no such grant support for personnel of Design Centers [13].

At the R&D/Design Centers founded based on the incentives and exemptions awarded by the Law with 5746 Serial number, R&D personnel and Designers are provided incentives such as memberships to national/international scientific libraries and data bases; and university research resources for personnel currently registered with graduate schools. In order to motivate R&D/Design Center personnel to participate in research and development activities, R&D/Design Center Award System Procedure is prepared. In this scope, personel award system is targeted for patent, industrial design, projecets, publications and etc. Personnel also participate in academic cooperation and various scientific summits and symposium [13].

According to the 4th Article of the Law Regarding Incentives to Research, Development and Design Activities Law with 5746 Serial number, "Supervisor refers expert persons or academicians who are assigned by the Ministry for supervising and monitoring applications and activities of businesses awarded project incentives of R&D center, Design center and pre-competition period. Supervizor checks whether businesses continue to fulfill the conditions of R&D/Design Center based on the given criterions [13]:

- Adequacy of business ratio of R&D expenditure to total sales,
- Confirmity of total R&D budget of business to its activities realized along the fiscal period,
- Harmonization between R&D strategies and business activities,
- Harmonization of future R&D plan to R&D strategies of the business,
- Existence of the business department in charge of governing Copyright, Intellectual and Industrial Rights when such outcome arise as a result of research projects,
- Existence of a systematic process in which innovative ideas of employees evaluated by R&D management,
- Adequacy of number/quality of R&D/Design projects conducted in a period,
- Existence of information management system in the facility (information storage, sharing, management and security),
- Existence of cooperative studies with the universities under R&D/Design activities,
- Quality and quantitiy of scientific technological publications, articles and symposeums, presentations,
- Adequacy of applied or endorsed patents,
- Ergonomic appropriateness of R&D/Design Centers,
- Appropriateness of infrastructure of current machine equipment and laboratory,
- Adequacy of R&D, innovation and design activities for maintenance,
- Adequacy of educations of R&D/Design personels [13].

According to the bulletin of "Budget, Allowance and Expenditures Spared From the Central Management Budgets for Research and Development Activities, 2018" published by Turkish Statistical Institute (TÜİK), R&D expenditures in Turkey constitutes 0.35% of the GDP and 1.4% of Central Government Budget expenditures. According to provisional results based on initial budget appropriations, our country has allocated 15 billion 597 million TL on R&D for the budgetary year 2019. With the linear correlation between R&D expenditures and GDP, upswing in R&D expenditures results in positive impact on GDP.

Technocities are different from each other in terms of their organizations, objectives, operations or administrative structures. It is quite difficult to describe a single scope for Technocities [14]. Various descriptions drawn so far were presented below:

According to the International Association of Science Parks (IASP):
Under management of expert personel, the essential target of a science park (SP) is to expand innovation culture across computer science companies, motivate competitiveness to elevate welfare level of the region. In order to reach essential target, they control information and technology stream among Technocities, universities, R&D/Design Centers and companies; encourages foundation and growth of innovation-based companies through supporting incubators and "spin-off"; and provide high-quality service with value added in high quality work place and opportunities [14].

According to the Technology Development Area Law with 4691 Serial number:
Technology Development Area is a place in which technology/computer programming activities developed by high/advanced or new technology user companies, which utilize from facilities of a university, high technology institute, or R&D Center. Companies located in this region conduct activities which contribute in the domestic development process by transforming a technological invention into a commercial product, method or service. Technology Development Area refers an area in which a university, high technology institute, R&D center or institute campus are coalesce in the same or nearby locations in terms of academic, economic and social perspectives [15].

According to the Technology Development Area Association (TGBD):
Technopark an organized research and business development ecosystems in which universities, research organizations and industrial organizations carry out research, development and innovation studies under the same roof and share information and technology, integrate academic, economic and social structure [16]. Technology development areas could be referred as Science Park, Technology Park/Technopark, Technopolis/Tecnopol, Research Park, Technology Development Area, Technology Development Center, Technology Corridor and Innovation Center in different countries. In Turkey, as it is prescribed by the Law with 4691 Serial number, "Technology Development Regions" are regulated by this law. Furthermore, Technopark/Technocities concept are used more extensively.

2.2. Technocities in the World and Turkey
In various resources, it is known that Technopark activities have started with Silicon Valley - Stanford Research Park in the world in 1951 [14]. Today, hundreds of global companies such as Google, Intel, Microsoft, Xerox, Apple, Adobe Systems, Yahoo and DataSign are located in this Technopark. Afterwards, Research Triangle was founded in Northern Carolina in 1959. Some of the world's largest Technoparks are given as follows: Silicon Valley, Massachusetts Technology Institute, Research Triangle Park in the US; Herriot Watt Research Park, Science Park (Cambridge), Science Park (Merseyside), Science Park (Oxford) in the GB; Sophia Antipolus, Grenoble (Meylan), Taulose in France; Oulu Teknolip in Finland; and Brno Technology Park in Czech Republic [17].

Turkey's technology-oriented initiative was formed with Turkish Scientific and Technological Research Institution (TUBITAK) in 1963 to coordinate, organize and support fundamental and applied scientific researches. Since 1960s, the basic policy to strengthen small industry businesses in Turkey has been increasing number of small industry sites. The main reason for this approach was to consolidate these organizations in certain locations so as to elevate manufacturing and market potential. The idea of establishing technocities in Turkey emerged together with four universities and Small and Medium Industry Development Organization (KOSGEB) in 1990; and the relevant legislation about 'Technology Development Regions" was enacted in 2001.

Under the scope of the Technology Development Regions Law whose target is to meet private sector with researchers and universities toward developing products and manufacturing methods by technology-intense manufacturing, supports and exemptions are provides to maintain and encourage sustainability of university-industry cooperation. Under the scope of the Technology Development Regulation Law with 6170 Serial number [18] enacted on 12.03.2011, companies are provided incentives such as "Corporate and income tax exemption; VAT exemption; Insurance Premium support; tax exemption for R&D personnel wage; tax exemption for support personnel wage, rational external region employees support; R&D investment support" [18]. These incentives and exemptions allow Technocity companies to orient on technology development and research activities.

As of February 2020, 67 out of 85 Technology Development Areas have continued their activities; and 18 of them have not been commissioned yet due their ongoing infrastructure works. In the Technology Development Regions, when intellectual and industrial property rights are considered, it could be seen that number of registered patents (national/international) have reached 1.132; number of registered utility model has reached 409; and number of registered industrial design has reached 122. When industrial distribution of Technology Development Regions is considered, computer programming activity has the highest portion by 43%. Number of active R&D Centers has reached to 1.236. In industrial distribution of R&D Centers, "Machine and Equipment Manufacturing" industry has 181 R&D Centers with the highest share. Number of active Design Center has reached to 371. In industrial distribution of Design centers, "Textile" industry has the highest share with 70 centers [18]. Within the scope of "Technological Product Investment Support Program (Teknoinvestment)" which aims commercialization of high technology products and increasing and ccelerating investment on these products, contracts for 204 projects from 26 cities were executed between Ministry and businesses under the scope of Technological Product Investment Support Program. Of these 204 projects, 91 have been completed and the Ministry transferred totally 72.795.881,30 TL to these businesses for machine and equipment support [19].

In parallel with development of Technocities, it was expected the companies incapable of sparing adequate resource of R&D investments was to be supported and technical information created by universities was required to be commercialized. Thus, it was aimed that all stakeholders in the triangel of University-Government-Industry could prosper [19]. TUBITAK Technology and Innovation Support Programs Directorate (TEYDEB), TUBITAK Research Support Programs Directorate (ARDEB), TUBITAK Scientist Support Directorate (BIDEB) and TUBITAK Science and Society Directorate were included in this system. Among the public research institutes, there are Turkish Atom Energy Institution (TAEK) and National Boron Research Institute (BOREN). They have been technological actors to support innovative activities and competitiveness of Small and Medium Sized Businesses (KOBI) [20].

Technocities make contribution into employment growth, development of education level, and development in their territory; and support industrialization by contributing into regional industrial competitive strength, decrease national unemployment level, improve country's global reputation, develop specialized labor; enhance science and technology level of a country, and allow country's openness to international markets [21].

2.3. R&D Expenditures

Advanced technologies currently represent "the Fourth Industrial Revolution" displaying potential for EU industries and for economic growth in European economy. Instead of creating new industries, the largest digital opportunity is the transformation of current industries and businesses. In a survey study conducted with EU companies, 75% of participants viewed digital technologies as opportunity. 64% of the companies invested in digital technologies have gained pozitive results [22].

In some countries, initiative of I4.0 policy is the direct result of national framework and strategy. I4.0 was launched as one of the 10 future projects mentioned in the 2020 German Action Plan High-Tech Strategy. In Spain, strengthening of industry transformed in to "*Industria Conectada 4.0*" was digital content of the agenda. Although there are common targets, some discrepancies may arise about policies and how to accomplish economic targets. Many countries, especially Germany, focus on acquiring higher productivity and efficiency. I4.0 example in Germany indicates how a large I4.0 platform could reduce industry distinction and to develop network.

R&D, involved in every stage of our lives, is directly related to human life. The availability of the necessary infrastructure ensures the development of science and technology in a country. The world of technology is changing and improving every day. Technology with its inventions offered to the service of humanity in silent and constant motion. R&D studies in developed countries brought high-tech into its current state.

R&D is substantial for technology companies and it is seen that they do not abstain from investment into R&D (Table 1). In 2018, Amazon stands out as a technology company with the highest R&D expenditures. As Amazon is recognized as the most-customer-oriented company of the world, it could be understood that the company accomplished to implement Industry 4.0 practices. R&D expenditures is not only important for developing self-innovation of a companyin, but also for constituting 3% of the GDP and for contributing into national productivity.

Table 1. List of Technology Companies Ranked with Respect to Their R&D Expenditures in 2018 [23].

2018	2017	Company	2018 Million $	Ratio to Income (%)	% Change from 2018
1	1	AMAZON	22.60	12.70	40.60
2	2	ALPHABET	16.20	14.60	16.30
3	5	VOLKSWAGEN	15.80	57.00	14.10
4	4	SAMSUNG	15.30	6.80	6.80
5	3	INTEL	13.10	20.90	2.80
6	6	MICROSOFT	12.30	13.70	-5.70
7	9	APPLE	11.60	5.10	15.30
8	7	ROCHE HOLDING	10.80	18.90	-8.70
9	12	JOHNSON&JOHNSON	10.60	13.80	16.00
10	8	MERCK	10.20	25.40	0.80
11	11	TOYOTA	10.00	3.90	2.60
12	10	NOVARTIS	8.50	17.00	-11.10
13	15	FORD	8.00	5.10	9.60
14	20	FACEBOOK	7.80	19.10	31.00
15	14	PLITZER	7.70	14.60	-2.70
16	13	GENERAL MOTORS	7.30	5.00	-9.90
17	16	DAIMLER	7.10	3.60	-9.20
18	19	HONDA	7.10	5.40	8.70
19	24	SANOFI	6.60	15.10	5.80
20	23	SIEMENS	6.10	6.20	4.90
TOTAL FIRST 20			**214.70**	**11.60**	**7.30**

Table 2. List of Turkish Companies Ranked with Respect to 1000 Companies with the highest R&D Expenditure in 2018 [24].

Rank	Company	2017 Defence Income (Million $)	Defence Income (%)
366	ASELSAN ELEKTRONIK SANAYI VE TIC. A.S.	1.416	405
991	FORD OTOMOTIV SAN. A.S.	6.716	132

The scope of R&D activity consists of R&D expenditures, scientific and technical journal, high technology exports, patents, trademarks and the number of researchers. The results from the R&D indicators are important for the development of the countries. Table 2 exhibits the data published by Idea to value in 2018, which regards the Turkish companies with the highest R&D expenditures. Since defence industry is strategically important, the investment made in this industry make significant contribution into R&D and innovation. According to the published study, two (2) Turkish companies were nominated among the 1000 companies with highest R&D and innovation investment in the world.

Table 3. List of Turkish Companies Ranked with Respect to Their R&D Expenditures in 2018 [25].

2018	Company	R&D Expenditure (TL)
1	ASELSAN ELEKTRONIK SANAYI VE TIC. A.S.	2.162.839.458,00
2	TUSAS TURK HAVACILIK VE UZAY SAN. A.S.	1.575.962.278,43
3	FORD OTOMOTIV SAN. A.S.	666.587.048,67
4	ROKETSAN ROKET SAN. VE TIC. A.S.	512.109.199,00
5	TURKCELL TEKNOLOJI ARAŞTIRMA VE GELIŞTIRME A.S.	397.236.556,35
6	VESTEL ELEKTRONIK SAN. VE TIC. A.S.	334.672.722,33
7	OTOKAR OTOMOTIV VE SAVUNMA SAN. A.S.	328.546.000,00
8	ARCELIK A.S.	308.921.540,40
9	HAVELSAN - HAVA ELEKTRONIK SAN. VE TIC. A.S.	302.391.497,96
10	TOFAS TURK OTOMOBIL FABRIKASI A.S.	268.872.000,00

Table 4. List of Turkish companies with the highest number of projects carried out in R&D centers in 2018 [25].

2018	Company	Project Number
1	ASELSAN ELEKTRONIK SANAYI VE TIC. A.S.	581
2	ARCELIK A.S.	498
3	AMCOR FLEXIBLES ISTANBUL AMBALAJ SAN. VE TIC. A.S.	350
4	VESTEL ELEKTRONIK SANAYI VE TICARET A.S.	320
5	DEVA HOLDING A.S.	263
6	SOKTAS TEKSTIL SANAYI VE TICARET A.S.	240
7	WORLD MEDICINE ILAC SAN. VE TIC. A.S.	200
8	EKOL LOJISTIK A.S.	198
9	CALIK DENIM TEKSTIL SANAYI VE TICARET A.S.	184
10	ZORLUTEKS TEKSTIL TICARET VE SANAYI A.S.	180

Table 5. List of Turkish companies according to the share of R&D expenditure amount from total turnover in 2018 [25].

2018	Company	Patent Number
1	VESTEL BEYAZ ESYA SANAYI VE TICARET A.S.	437
2	TURKCELL TEKNOLOJI ARASTIRMA VE GELISTIRME A.S.	378
3	TIRSAN TREYLER SANAYI VE TICARET A.S.	281
4	ARCELIK A.S.	276
5	ECZACIBASI YAPI GERECLERI SAN.VE TIC. A.S.	273
6	KORDSA TEKNIK TEKSTIL A.S.	178
7	TURAS GAZ ARMATURLERI SANAYI TICARET A.S.	168
8	TURK TRAKTOR VE ZIRAAT MAKINELERI A.S.	152
9	VESTEL ELEKTRONIK SANAYI TICARET A.S.	125
10	SANOVEL ILAC SAN. VE TIC. A.S.	80

According to the “R&D 250” and “Top 1000 Exporters” Researches conducted by Turkishtime based on the data from the Turkish Exporters Union and from the information obtained from the Public Disclosure Platform (PDP) [25], Aselsan is at the top of the list ranking the companies with respect to their R&D expenditures in 2018 with its 2.162.839.458,00 TL investment (Table 3). Aselsan spared 24% of its income to R&D and it was at the top of the list in 2017. As an exemplary company, Aselsan is a successful company that transforms its R&D activities into commercial products. Aselsan continues to expand its portfolio of new products based on R&D.

According to Table 4, there is a ranking of Turkish companies with the number of projects carried out in the R&D center. Aselsan ranked first among Turkish companies with the number of projects carried out in the R&D center in 2018. Arçelik A.Ş. and Amcor Flexibles İstanbul Ambalaj San. ve Tic. A.Ş. stood out as companies following Aselsan in 2018.

R&D and Innovation studies gain importance at this point. The products and services are expected to have their own R&D and innovation. Our products and servises should be differentiated from competitors' products and servises in order to be preferred more in international markets. This ensures that high value-added products are exported and the impact on the country's economy improves positively. So, R&D and Innovation activities should be compulsory so as to achieve a successful export performance and competitive advantage as a country. The increase in R&D indicator has a significant impact on Turkey's economic growth. Therefore, Turkey prioritizes R&D cooperation and innovation activities.

Similarly, as it is indicated by Table 5, with 437 patents, Vestel ranked first in the list. Automotive industry also continues to lead the R&D expenditures in private sector companies. T4E Energy is involved in the research as the company allocating the highest share from its turnover to R&D according to Table 6.

Table 6. List of Turkish Companies Ranked with Respect to Their Ratio of R&D Expenditure to Overall Sales in 2018 [25].

2018	Company	%
1	T4E ENERJI A.S.	74
2	VISPERA BILGI TEKNOLOJILERI SAN. IC VE DIS TIC. A.S.	66
3	ENMOS ENDUSTRIYEL OTOMASYON ELEKTRONIK VE IMALAT SAN. TIC. LTD. STI.	54
4	INTECRO ROBOTIK OTOMASYON AR-GE MUHENDISLIK MAKINE SAN. VE TIC. A.S.	48
5	OTTONOM MUHENDISLIK COZUMLERI TASARIM OTOMASYON DANISMANLIK A.S.	47
6	LOGO YAZILIM SAN. VE TIC A.S.	45
7	ARETE BILGISAYAR OTOM. DAN. VE EGT. HIZ. SAN. TIC. LTD. STI.	40
8	C.A.E BILGISAYAR DEST MUH. ARGE LTD. STI	40
9	OTOKAR OTOMOTIV VE SAVUNMA SAN. A.S.	33,37
10	TURKCELL TEKNOLOJİ ARASTIRMA VE GELISTIRME A.S.	29,8
11	GLOBAL BILGI PAZARLAMA, DANISMANLIK VE CAGRI SERVISI HIZMETLERI A.S.	28
12	TUSAS - TURK HAVACILIK VE UZAY SAN. A.S.	26
13	ROKETSAN ROKET SAN. VE TIC. A.S.	25
14	ILKO ILAC SAN. VE TIC. A.S.	25
15	BOYNER HOLDING A.S.	25
16	ASELSAN ELEKTRONIK SAN. VE TIC. A.S.	24
17	AKGUN BILGISAYAR PROG. VE HIZ. SAN. TIC. LTD. STI.	22,28
18	HAVELSAN - HAVA ELEKTRONIK SAN. VE TIC. A.S.	22
19	ASOS PROSES MAKINA SAN. VE TIC. A.S.	22
20	VEKTORA BILISIM TEKNOLOJILERI A.S.	20

When "R&D 250" research was considered [25], it could be seen that R&D was headed by automotive and defence industries in Turkey. Especially automotive industry is one of the significant industries in the world in terms of R&D. "R&D 250" list contained 34 automotive companies.

2.4. Comparison of Industry 4.0 Practices in the World and Turkey

Introduction of new generation technologies (Italy, the GB.), supporting SMEs for innovation and trade (the GB., France and Spain) to enhance industrial processes, developing new products (Germany, Italy) are seen among the most prominent targets. Development of the fourth industrial revolution in Turkey is crucially important because it would allow Turkey to take further step and enhance its competitive strength. In literature, there are various studies revealing studies and awareness of Technopark companies in this domain [17].

When survey and analysis results collected from Technopark companies regarding their considerations on Industry 4.0 transformation is focused, it could be seen that absolute majority of participants were managers and company owners (%56). Furthermore, half of the participants (51%) were the companies incorporated after 2010. It was observed with the companies founded after 2010 that they experience insufficient support problem higher than others. Moreover, companies with domestic capital could experience with technological problems higher in comparison with others. 83.1% of participants are located in Istanbul Technopark. Additionally, all companies included in the analysis were oriented on computer programming and engineering. Averages of companies sparing a protion more than half of their budgets to Industry 4.0 were found to be higher in terms of their focus on development of data management technologies from Industry 4.0 technologies and of their utility from employee skills and internal stakeholders. According to the analysis results of the study, variables were determined as success levels of companies from their individual expectaions, employee skills, infrastructure of product, service and labor force with regard to direct or indirect relationships to utilize from internal or external stakeholders win development process of Industry 4.0 technologies. Of these six variables, employee skills and infrastructure of product, service and labor force were found to be positively effective on company success from its expectations [17].

According to analysis results of the data collected from some companies located in Izmir and Manisa for assessing awareness of Industry 4.0 [26], the term of Industry 4.0 was found as the most commonly known term by participant companies by 23.36%. This was followed by Things of Internet (IoT) by 17.52%; factory layout by 16.06%; and large data by 16.06%, respectively.

Results of the survey results from the item of "Obstacles before Industry 4.0 Practices" emphasized "lack of necessary technologies and computer programming software, standards, knowledge, insufficient budget, and time and qualified personnel". Manufacturing area is regarded as the part of "Industry 4.0 with the highest value added area. Information technologies and supply chain cycle are other value added areas following the manufacturing area, respectively. According to the survey results obtained from the subject of "Solution of manufacturing problems by means of digitalization", it was seen that companies have higher expectations from Industry 4.0 especially with product, inventory and supply chain supervision. The results obtained from the survey questions on "Benefits of (AR-Augmented Reality) for companies" indicated that companies displayed positive results about augmented reality, simulation results, potential risks and results. Companies are expected to use robotic labor in manufacturing in the context of "innovation, robotic and automation" subjects. Moreover, digitalization of orders, assembly and manufacturing line is another demand of companies [26].

In Industry 4.0 application case in an automotive manufacturing factory in Turkey [27], RFID, E-Ink, Tablet, Google Glass etc. computer sciences technologies are combined in pilot application of paperless manufacturing concept under Industry 4.0 approach, afterwards of measurements and analyses, current automotive manufacturing and internal logistic processes were included and the system was tested. Results suggested that functional industrial tablets and Tags' high costs, and the fact that they are highly needed within the manufacturing processes caused investment return ratio of Industry 4.0 was very low; when it is considered that Turkey's labor force cost is relatively low, this make I 4.0 invesments return periods are substantially high. Positive results obtained from the pilot study after 3 years were taken into consideration and manufacturing tried under Industry 4.0 pilot work was expanded to other department of the factory. The pilot practice has brought numerous positive results. Intern-connected array of machineries and products elevated productivity; decreased costs; and thus saving from resources was made.

In addition to positive results obtained from the pilot practice, there were some negative results as well. It was realized that Turkish companies' desire to transform into I4.0 coulde be affected negatively because of high investment cost required for Industry 4.0. If Turkish companies are motivated through incentive mechanisms, it would be possible accomplish flexible, low cost manufacturing by low cost labor in Turkey owing to its geographical logistic advantage; thus, Turkey would attain important position within the global value chain. Developed countries, especially Germany, transferred its high-cost manufacturing facilities into low labor and low-cost manufacturing facilities. But, Industry 4.0 approach will be an exit for whole world, which would change global competition understanding, and reverse the process backwards, and to overcome macroeconomic problems.

In order to evaluate current status in Germany, a survey study was conducted as part of research regarding institutional readiness for Industry 4.0 by German 'Verband Deutscher Maschinen and Anlagenbau' (VDMA) by the German Union of Engineering over 268 companies each of which employs more than 20 workers [28]; according to the results, 56.5% of participant companies did not have met with any condition regarding readiness for Industry 4.0. Moreover, 20.1% of companies were at the Beginning 1 Level which implies that the relevant company took initiative by applying pilot Industry 4.0 practices in its various departments and made certain investments. Only 0.3% of companies (8 out of the 268 companies) were ranked as Level 5 (the best performer) cathegory. This means that the companies at this level were alredy at some point in practice of Industry 4.0 strategy and they adequately considered the subject well.

2.5. Industry 4.0 Status Analysis

To get the most benefit by using limited resources at the lowest cost has formed the basic philosophy of today. Therefore, it is necessary to make a strategic analysis as a country and take into account the parameters that will carry our country to the level of international standards in terms of the scope and concept of R&D and innovation activities.

Table 7 exhibits R&D-Design Centers' SWOT (Strong - Weak aspects/Opportunities -Threats) Analysis results. The matrix created based on the results of the Swot Analysis is an assessment of strong, weak, opportunity and threats of Industry 4.0 and R&D-Design centers together with all dimensions of system.

Swot Analysis is a model allowing considering, comparison and selecting the most appropriate alternative for strategic planning by assessing future vision, internal and external factors of a company. From the SWOT analysis conducted on the R&D-Design centers trying to apply Industry 4.0, they need qualifief human resource competent on automation as well as machine-machine and human-machine interaction. All deficiencies are required to be left behind; strong aspects are to be supported by opportunities for creation of state of the art products. Sustainability of R&D and innovation need to be ensured for higher economic growth potential. This study tried to describe Industry 4.0 to introduce a scientific assessment. Within scope of the Industry 4.0 practices, SWOT Analysis of R&D-Design Centers was presented.

Table 7. Swot Analysis of R&D/Design Centers In Pursuit of Industry 4.0 Practices

Strengths	**Weaknesses**
▪ Fast technology adaptation capability ▪ Domestic market ready for demand ▪ Convenient access to overseas market / distances ▪ Low investment costs ▪ Attaching greater importance of R&D activities due to recognition of innovation and quality concepts in manufacturing ▪ Appropriate environment in which Market, manufacturing and R&D are existed all together ▪ R&D opportunity for unfulfilled domestic needs	▪ Deficiencies in practice of policies and lack of coordination among institutions ▪ Insufficient technology of current infrastructure ▪ Expansion of legal scope of Technocities ▪ Failure to commercialization of know-how and technology ▪ Lack of inventive and innovative culture, weakness in creation of technological innovation ▪ Lack desire among academicians to transform their ideas/ studies into concrete products ▪ Poor cooperation level between core industry/supplier industry ▪ Inadequate expert R&D personnel with PhD degree ▪ Lack of R&D infrastructure support for SMEs
Opportunity	**Threat**
▪ Creation of state of the art products ▪ Incentives ▪ Sustainability of investment climate ▪ Economic growth potential ▪ Development potential for computer programming ▪ Potential for initiate extensive R&D projects	▪ Unemployment pressure ▪ Academic education quality ▪ Change in manufacturing costs ▪ Supply of valuable commodity ▪ Energy ▪ Legal issues ▪ Economic crises ▪ More institutionalized and more investor-friendly R&D incentive programs in rival countries

Over four different scenarios, the advantages which could be given by Industry 4.0 application to companies through R&D/Design Centers were explained based on scientific foundation (Figures 3-6). The red colors in figures denote the issues in the relationship between Industry 4.0 and R&D/Design Centers need greater attention subject to their potential negative impact on the system.

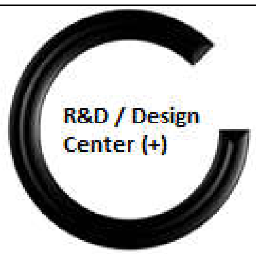
	• Product Variety ▲ • System Modification Opportunities ▲ • Continious Feedback ▲ • Error Rate ▼ • On-Site Control Systems ▲ • Personalization (Modiularity) ▲ • Flexibility ▲ • Complexity ▲ • Need for Labor ▼ • Maintenance Details (Cost & Complexity) ▲ • Dependency to External Resources ▼ • Capability of Immediate Intervention ▲
	• Capability of Orienting on New Potential Areas in the Industry ▲ • Capability of Raising Competent Personnel ▲ • Number of Skilled Personnel ▲ • Education Activities ▲ • Innovative Design Capacity ▲ • Difficulty of Integration of New Systems ▼ • Additional Resources Necessary for R&D Center ▲

Figure 3. Scenario I [Industry 4.0 (+) and R&D / Design Center (+)].

Figure 3 exhibits Scenarios I [Industry 4.0 (+) and R&D/Design Center (+)]. These scenarios indicate the parameters of the most-desired and target status. Figure 6 exhibits Scenarios IV [Industry 4.0 (-) and R&D/Design Center (-)] which reflects the status analysis of an undesired circumstance. In this case, companies are required to reevaluate their organization structures, design & manufacturing processes and their capabilities for a fast-paced Industry 4.0 adaptation.

	• Product Variety ▲ • System Modification Opportunities ▲ • Continious Feedback ▲ • Error Rate ▼ • On-Site Control Systems ▲ • Personalization (Modiularity) ▲ • Flexibility ▲ • Complexity ▲ • Need for Labor ▼ • Maintenance Details (Cost & Complexity) ▲ • Dependency to External Resources ▲ • Capability of Immediate Intervention ▼
	• Capability of Orienting on New Potential Areas in the Industry ▼ • Capability of Raising Competent Personnel ▼ • Number of Skilled Personnel ▼ • Education Activities ▼ • Innovative Design Capacity ▼ • Difficulty of Integration of New Systems ▲ • Additional Resources Necessary for R&D Center ▼

Figure 4. Scenario II [Industry 4.0 (+) and R&D / Design Center (-)].

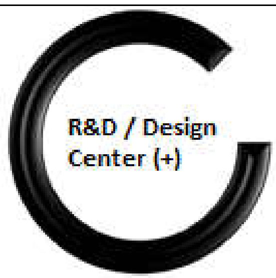
	• Product Variety ▼ • System Modification Opportunities ▼ • Continious Feedback ▼ • Error Rate ▲ • On-Site Control Systems ▼ • Personalization (Modiularity) ▼ • Flexibility ▼ • Complexity ▼ • Need for Labor ▲ • Maintenance Details (Cost & Complexity) ▼
	• Capability of Orienting on New Potential Areas in the Industry ▲ • Capability of Raising Competent Personnel ▲ • Number of Skilled Personnel ▲ • Education Activities ▲ • Innovative Design Capacity ▲ • Difficulty of Integration of New Systems ▲ • Additional Resources Necessary for R&D Center ▲

Figure 5. Scenario III [Industry 4.0 (-) and R&D/Design Center (+)].

	• Product Variety ▼ • System Modification Opportunities ▼ • Continious Feedback ▼ • Error Rate ▲ • On-Site Control Systems ▼ • Personalization (Modiularity) ▼ • Flexibility ▼ • Complexity ▼ • Need for Labor ▲ • Maintenance Details (Cost & Complexity) ▼
	• Capability of Orienting on New Potential Areas in the Industry ▼ • Capability of Raising Competent Personnel ▼ • Number of Skilled Personnel ▼ • Education Activities ▼ • Innovative Design Capacity ▼ • Difficulty of Integration of New Systems ▲ • Additional Resources Necessary for R&D Center ▼

Figure 6. Scenario IV [Industry 4.0 (-) and R&D/Design Center (-)].

Sub concepts such as digitalization, intenret of things, cloud and large data emerged with the core Industry 4.0 concept have potential for extensive changes in many industry areas. Although these concepts may not reflect their significance at the first sight, they open door to critical advancements in terms of saving from human labor, operator interventions and need, acceleration of processes, and remarkable cut from error rates. It is assumed with cloud systems that data access could globally be controllable; usage of this huge data undoubtedly requires additional measures. Companies would be able to protect their data by cyber security systems and integrate Internet of Things, another aspect of Industry 4.0, into their systems. Data processing and selection capacity called big data will be among other requirements. After realization of this basic infrastructure, many sub-processes causing waste of time would be eliminated; number of human labor and operator would decrease; and less manufactuinr errors would become possible. Figures 7 and 8 consider manufacturing activities in these regards.

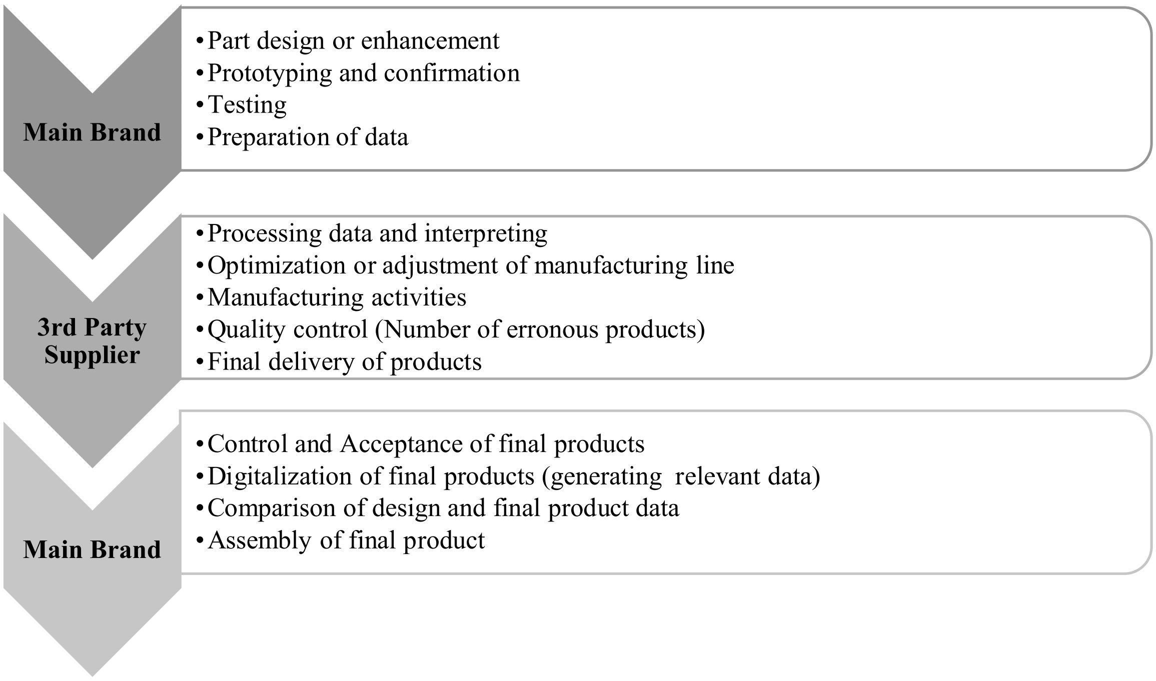


Figure 7. Main Brand withouh Industry 4.0 Application – Supplier Manufacturing Activity Case

Manufacturing processes, starting from design depart to all, would gain pace as the digitalization, data transfer over cloud, compilation, dechiphering of data taken from redealer and supply of necessary competent human capital. Additionally, human-born errors would be eliminated among processes. In the following illustration, an example in which Industry 4.0-integrated sensor networks and intelligent robots through Internet of Things could send and receive feedback from each other was taken into consideration. This example indicates that system flexibility, product optimizations and corrections would be implemented conveniently so that higher excellence could be possible with manufacturing.

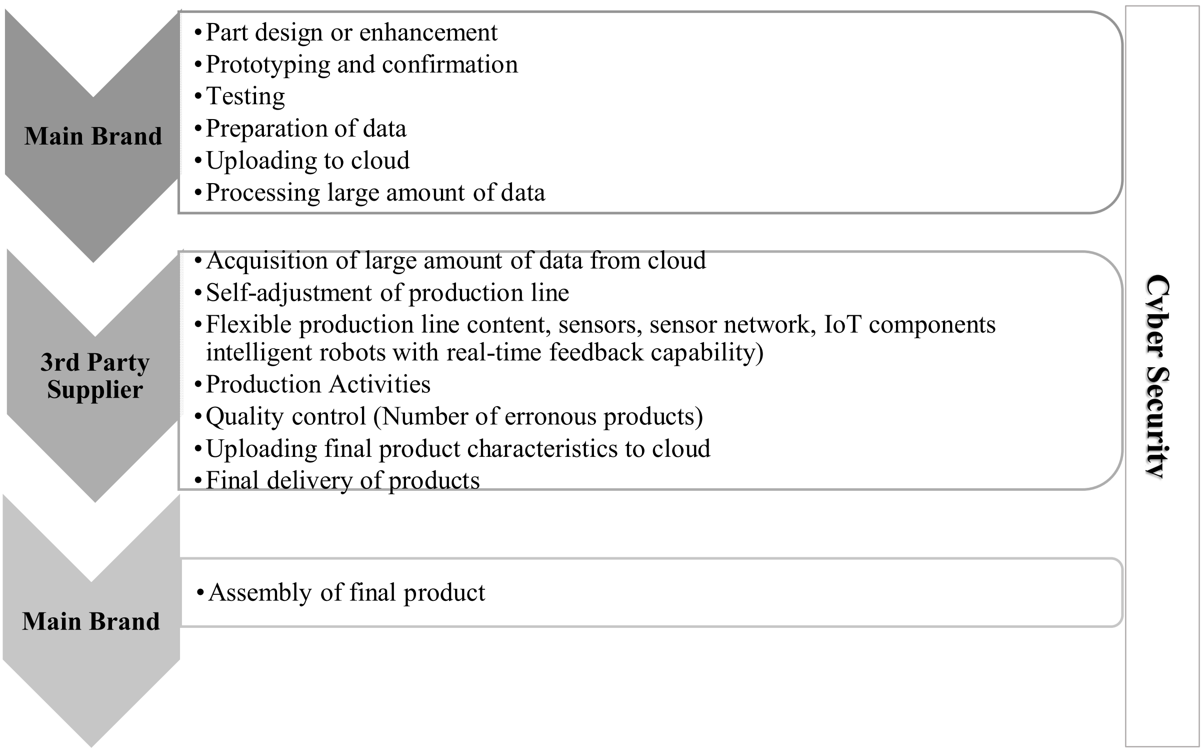


Figure 8. An Example of Industry 4.0 Application: Main Brand – Supplier Manufacturing Activity.

Design centers could utilize from innovative concepts such as big data and cloud in various forms; and they could gain pace with their new designs and improvement processes. Along the design process, it would be possible to pull the key variables in a model directly from cloud so as to gain progress in the prototyping phase. For instance, simultaneous accessibility to thickness of metal sheet and windshield dimensions would significantly facilitate manufacturing process of insulation rubbers of windshields. Moreover, different design groups could prepare alternative solutions for the very same design problem simultaneously; or different components could be designed simultaneously after retraction, compilation and processing of the data from cloud. Such integration carries significant potential for downsizing data transfer and data processing needs. Design process could be adaptive and flexible by allowing collection of analysis and assembly data on the cloud as a resource for all sub-processes and other potential third party suppliers and uninterrupted manufacturing process as well as immediate accessibility to all possible amendments.

Industry 4.0 could also be utilized for e-commerce activities. Designers especially might face difficulties with accessing 2D or 3D data of beginning parts that they use in e-commerce environment. In the design process, it is assumed that by utilization from big data to retract data of previously designed parts from cloud to facilitate designers to generate advanced technology products. Ofcourse, cyber security is required to monitor private copyrights and privilages on cloud and misconductive activies are required to be prevented on this new platform. Another example of commissioning of big data and cloud is in decoration and furniture industry. For example, 3D house or office plans could be accessed from the cloud; and relevant furniture could be designed for the specific homes and offices. Such innovations could save substantial time for consumers by shortening their furniture shopping time.

Another Industry 4.0 example is that machine manufacturers use cloud data to eliminate conformity problems of median parts (bearings, reduction gears, shafts, beds etc.) playing significant role in assembly activities with frame and final products. Through big data, data obtained from cloud could be processed to confirm the most appropriate design so that error margin could significantly decrease. For instance, users from automotive industry have measure characteristics of cylinder head. They are capable of storing extensive data regarding, materials, manufacturing process and manufacturing conditions. Thus, all data regarding cylinder head could be stored in a single data base. Owing to digitalization of sensors, actuators and benches used in facilities, zero-error manufacturing could be acquired and this addresses the importance of integration of software bridging consumers with manufacturing systems.

2.6. Effects of Industrial Revolution in the World and in Turkey

Automation, machines and internet communication among things, the requirements of the fourth industrial revolution, are irreplaceble elements of high-tech. Halflife of product or business strategy has shortened and their pace has accelerated due to especially increasing complexity and numerous consumer demands. In such new environment, success requires agile, innovative, and quick-decision maker businesses and factories. As it could be implied from the scenarios established within the scope of the present study, Industry 4.0 does not only refer how to enhance function of manufacturing as a whole, but also it assumes to evolve individuals in the factory field. It plans to intense the connection among all personnel and different departments by eliminating obstacles. Moreover, it aims to gain capabilities of specialization of orders, relieving stress of individual workers, and fulfilling expectations of consumers. Industry 4.0 yields a new version of personalized manufacturing epoch and combines personalized manufacturing with the contemporary consumers’ expectations of fast and timely delivery. Industry 4.0 allows employees to leave difficult tasks to machines and to have opportunity to focus on important ones. Increasing number of manufacturers have concentrated on special applications of Industry 4.0 and gained substantial improvements.

Integration of Internet of Things with cyber physical system technologies exposes brand-new opportunities in the future. Manufacturing system control is not only limited with material and machines, devices, or physical components, it is capable of processing vast amount of data on real-time basis. This process takes place in three integration phases in manufacturing: vertical integration, horizontal integration and end-to-end integration. Vertical integration considers the issue of uninterrupted connection among all factors included in an organization included in product life cycle. On the other side, horizontal integration takes place in case of intimate coalescence of a company with its suppliers and partners. Finally end-to-end integration allows complete system integration from factory ground to consumers and products. At the factory ground, integration from one machine to another is allowed so that machines to be replaceable part of manufacturing system. Secondly, integration of consumers to manufacturing system could be possible and thus, engineers could access consumer feedbacks conveniently and timely. The thirdly, service-product integration is ensured for products in use of consumers so that manufacturers could directly monitor them [29].

There are standards needed to ensure data exchange among machines, systems and software, constituent of value network. Furthermore, standardization is required to allow robots to integrate into the system through a plug-and-play convenience. If data and communication protocols are described as special or only national, only some companies' equipment would be compatible. In this case, competition and commerce would adversely be influenced and associated costs would be elevated. On the other hand, independent, generally accepted, internationally standard communication protocols could allow compatible function among data formats and interfaces in various industries and countries in harmony. Thus, extensive perception of Industry 4.0 technologies could be motivated and world-wide open markets could be reached from European manufacturers and their products.

Amount of data collected within the scope of Industry 4.0 increase expectations of consumers from the feedback that they provide about the goods they bought. Accordingly, manufacturers could benefit from digital supply chains. This technology allows factory administrations to monitor factory material supply and product demand on real-time basis. Manufacturer could utilize from these data to provide end-to-end supervision capability during their product survey and to fulfill their knowledge needs regarding the product that they invest. Besides monitorability, consumers expect transparency to increase. Now that, manufacturers could utilize from digital platforms to monitor all product information during manufacturing. Factory administers could monitor products along manufacturing process and make these information accessible for consumers at sales points. This new technology provided to consumers could be specialized with respect to consumers' their own requirements to attain higher value added onto their ultimate products. Before manufacturing the ultimate product, businesses need to make sure that they fulfill expectations of consumers by means of virtual reality (VR) and augmented reality (AR) tools. Thus, consumers would be able to try their goods in virtual environment before purchasing them to ensure everyone's satisfaction. Timely delivery of products is basic constituent of consumer satisfaction. In order to ensure manufacturing process to function according to the program, facility managers avoid production line failure because this might jeopardize product delivery time, which could damage the brand. Facility managers could prevent unexpected and costly production line failure time by implementing planned maintenance activities. By following status check procedures, facility managers could determine potential failures in advance and prevent their breakdown. To carry this step one step further, manufacturers could employ intelligent spare part logistic for managing order process before they run out and to determine the most reliable supplier. Thus, probability of cancellation of an order by a consumer is minimized and it is ensured that failure times could be avoided by manufacturers. Consumer expectations are still in the center of attention. İntelligent manufacturer factories make it possible to provide more detailed information to consumers about the products purchased by enhancing data in terms of both quantity and quality.

Similarly, Industry 4.0 improvements pave the way for increasing personalization in the manufacturing process. For instance, introduction of 3D printing more extensively as main manufacturing process means that consumers will be able to personalize their products totally in some industries. Manufacturers utilizing from this technology are capable of creating tailor-made products on the expense of manageable costs. A new technology like 3D printing could help fast prototyping owing to significantly reduced delivery dates. Hence, manufacturers are capable of relatively low cost value added from their consumers. With the supply chain operation which could match real demands closely and provide necessary flexibility to adjust unforeseen conditions, more reliable supply stream could be gained. This means that consumers could have timely delivery; and they place orders in the future more confidently.

New starters in the automotive industry, Google, Tesla, Uber, Faraday Future, Atieva, Renovo Motors and Divergent Technologies, realized significance of big data and their analytics; and established their strategies in detail to design their vehicles and relevant mobility services. From an automobile part, wide range of information could be traced such as whether is from passenger car or public infrastructure; and whether it is related with function of the vehicle or travel comfort. For instance, autonomous driving requires collection of much more data than the personalization of in-vehicle entertainment options according to the driver's choice. Moreover, automobile manufacturers need to learn how to build drivers' data networks. Data networks would allow harvesting and compiling data from drivers by means of applications such as Waze regarding their real-time traffic warnings and real-time public transportation notifications. In the latest models, in-vehicle data management system uses portion of embedded systems, map data, guide data, and certain entertainment content. These data is required to be uploaded on cloud periodically. Data and models employed for personalization of vehicle based on passenger's preferences could be found on cloud. Multiple sensors such as a radar, camera and lasers used for collection of periphery information and integration of collected data. For transfer of data, automobiles connected to the cloud system could be able to utilize from music, video, e-mail and etc. entertainment and productive applications. For gathering meaningful information from collected data, some companies led by Google have launched more complicated Deep Learning Systems to develop navigation competencies of autonomous automobiles. Finally, data security poses great risk against hackers who could infiltrate in autonomous vehicle data.

3. RESULTS

So far today, majority of industries have adapt and apply machines and operations provided Industry 3.0 as much as the existing automation capabilities allow them. The new philosophy of the Industry 4.0 epoch is to digitalize all manufacturing assets from beginning to end; and to integrate vertical and horizontal value chains to a digital ecosystem. The primary condition is to generate, analyze and transfer of data without any hassle. This relies on various integrated networks and technologies to create value and to gain competitive strength. Since this novel manufacturing environment has been adopted by industrial companies, Industry 4.0 has gained popularity across the world. It is foreseen that Industry 4.0 Revolution would have impacts on employment, sustainable competition, social, environmental, innovative, and research developments.

This study presented a scientific evaluation on Industry 4.0 by providing a description. SWOT Analysis was conducted on R&D/Design Centers in an effort to pursue Industry 4.0 applications. Additionally, significance of R&D/Design Centers, as requirement under Industry 4.0, and their potential advantages were tried to be revealed through four different scenarios for companies on scientific ground. Importance of Industry 4.0 was tried to be explained through comparisons of main brand holder or supplier companies with or without Industry 4.0 applications.

Industry 4.0 concept is not only limited with direct manufacturing in the company, but also it includes a complete value chain from suppliers to consumers, all commercial functions and services of company. "Industry 4.0 Revolution" plans to integrate artificial intelligence, Internet of Things, artificial neural networks, cloud technologies and other similar things to organization worlds and manufacturing processes. The objective of the Industry 4.0 Revolution is a manufacturing model in which all mechanical or human elements are communicated with each other through internet or local networks. Entrepreneurs are required to be ready for updating their current practices and for potential developments by considering all these developments. Furthermore, they need to comprehend these concepts and accomplish individual & organizational transformation.

Global society has experienced four fundamental industrial revolutions which have totally evolved the industry along the last 250 years. The most prominent determinant on successes of industrial revolutions is our effort to organize education system. Therefore, educational paradigms are required to be rebuilt. Industry revolution could be sustained on the condition that country education system is maintained through flexible, tailor-made curriculum, superior guidance by teachers, and an administration approaching students as individuals to raise them competent intellects. An equitable and sustainable system which provides students, tomorrow's labors, life-long learning opportunity and self-discovery in terms of their strengths needs to be established. In order to ensure Turkey's success in industrial revolution, it is vitally important to adopt the education policies followed by other successful countries. Industry and university cooperation in terms of R&D is of critical importance. Industry - university cooperation provided in technoparks. Due to importance of country position in global market, like all other countries, Turkey would inevitably find its place in Industry 4.0. A comprehensive development effort is required for accomplishing this transformation effectively.

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