Industry 4.0 and Smart Production

İsa Gerekli¹, Tarık Ziyad Çelik², İbrahim Bozkurt³

¹ Sütçü İmam University, Kahramanmaraş, Turkey

² Gaziantep University, Gaziantep, Turkey

³ Kilis 7 Aralık University, Yusuf Şerefoğlu Faculty of Health Sciences,
Department of Health Management, Kilis, Turkey

Abstract – Industry4.0 is a popular topic in today's ecosystem. Many businesses that have high profitability, sustainable unlimited lifetime and high efficiency will be able to integrate Industry 4.0 technologies, which emerged in Germany in 2011, into their businesses and meet changing customer demands. On the other hand, they will be able to gain competitive advantage with this new technology. The concept is defined as a process in which an advanced level of automation is applied over a virtual network, the machines make decisions by communicating with each other, the data collected with the help of sensors are stored in the cloud system through these virtual networks, and used by all stakeholders integrated into the system when needed. In this study, it is aimed to explain what the Industry 4.0 technologies conceptualized in 2011, the concept of smart production and the benefits of these technologies to businesses.

Keywords - Industry4.0, Smart Production, Industry4.0 Technologies

1. Introduction

On the basis of opinion differences in all of the industrial revolutions that have been realized until today, the question of “Where do these revolutions

take humanity?” has remained a question mark in the minds of all shareholders.

In addition to dynamics that trigger industrial revolution is a product of an idea which always wants more. They are described as opportunity and effort to increase efficiency and hold organization cost at minimum [1]. While the trigger factor in the mechanization that began with the 1st Industrial Revolution was the invention of steam-powered machines, the use of this energy in the machines contributed to the increase of efficiency with the discovery of electricity in the 2nd Industrial Revolution. The development of information technologies contributed to the emergence of new approaches. 4th Industrial Revolution caused the reinterpretation of known several truths. This technological revolution first appeared in Germany and differs from other revolutions with its structure. This revolution [2] that has a structure, covering the development of new generation technologies and their integration into system in which physical and cyber world coexist, is an ecosystem in which people work in a more strategically oriented areas. Machines and robots are used in the production; devices have the ability to make decisions with algorithmic calculations.

We are faced with a lifestyle that turns into the world of several smart devices, from smart homes to smart cars that connect with each other, make life more comfortable for people, with ecosystem, technologies of internet of things. Production businesses also have their share of all these developments. Businesses that aim to be sustainable show great interest to these new technologies, which enable to make private, flexible production, in order to keep up with this change. With these new smart manufacturing technologies to be acquired, businesses will provide themselves big advantage within the competition by both increasing their productivity and decreasing their costs. The adaptation of developed countries, in which labour costs are high, will cause increase the differences with the developing countries within the level of income. When considered from this point of view, the adaptation of developing countries, which have a

DOI: 10.18421/TEM102-37

<https://doi.org/10.18421/TEM102-37>

Corresponding author: İsa Gerekli,
Sütçü İmam University, Kahramanmaraş, Turkey.
Email: isagerekli@hotmail.com

Received: 24 December 2020.

Revised: 10 April 2021.

Accepted: 18 April 2021.

Published: 27 May 2021.

© 2021 İsa Gerekli, Tarık Ziyad Çelik & İbrahim Bozkurt; published by UIKTEN. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 License.

The article is published with Open Access at www.temjournal.com

voice in the production with the contribution, provided by a downward move in the labour costs, to these new technologies, has become more significant in order to protect their existing workloads.

2. Literature

In this chapter of the study, Industrial Revolutions revealed by new technological developments and differences between these developments are analysed with literature review. In addition, findings, obtained from several studies in the literature review, enable us to determine benefits of new technologies for businesses and people. The appearance aim of all Industrial Revolutions is to increase the efficiency of production activities of inventions during their own period [3]. When considered within these results, case, which is accepted as the first leg of change, is the change which started in England in the middle of 18th century. Later, this change expanded to Europe then the entire world [4]. Before the discovery of machines, textile was accepted as the sector, in which production rate was highest, in the production sector. It was United Kingdom, at the highest level in this sector at that time, which enabled rapid transition to mechanization in the textile sector [5]. When all Industrial Revolutions considered, while the need for labour force decreased with every revolution, the need for qualified worker always increased and the abilities of workers gained importance rather than the number of workers [5]. It is generally accepted that Industrial Revolutions go through four stages, it is an unquestionable fact that new technologies have accrued to previous technologies with transitions between revolutions and engineering applications have been vital in every industrial revolution. Contents and periods of four industrial revolutions are explained in Table 1.

Table 1. The Chronology of Industrial Revolutions [6]

During the 1st Industrial Revolution, mechanization showed increase after the use of coal instead of wood and bio fuel and the discovery of steam-powered machines [7]. With the use of steam-powered machines in textile sector, several changes have emerged [8]. These developments in the industry brought increase in the supply of commercial goods with intense mass-production which emerged after the revolution. This ended up with decrease in unit costs and abundance of supply. Concordantly, significant decreases in prices happened [9].

The period, called Industry 2.0, included a time period, started in 1870 and continued to 1989. The most important issue in this period was the used of electricity in the production [10]. This new discovery enabled machines to be used more ergonomically and efficiently. Therefore, countries that gained strength by means of electricity specialized in chemistry, oil, plastic and steel sectors [11].

After two revolutions, if we consider the realization of the third industry and whose development triggered this revolution, concepts like Information, Bio-Technology, Nano Technology and communication technologies were accepted as the pioneers of revolution [11].

Third Industrial Revolution enabled the discovery of PLC (programmable logic control) with the digitally programming of Modicon automation systems in 1969. These developments made possible to obtain flexible and efficient productivity [8].

The concept of Industry 4.0, defined as a new ecosystem in 2011, aims to enable businesses to analyze big data real-timely and make strategic and operational decisions by having flexible production processes [6]. According to Özel, the aim of 4.0 is to enable lower production cost and make production faster, cheaper and also more qualified and less wasted by using robots that are connected with each other. Similarly, the aim is to analyze data, perceive the process with sensors, and additionally realize the needs in the production. In the development from 1st Industrial revolution to industry, in 4.0 goods are produced in a more people-oriented way in today's production facilities, reaching today's requirements of production processes and having smart production facilities as sustainable business facilities, which impel its importance [6]. This development in the industry revolution is the use of cyber systems and physical systems together.

3. Industry 4.0 Technologies

Industry 4.0 does not have a homogenous structure which is limited with internet technologies. Besides being a situation in which goods, produced by production systems interconnect and physical data is

retrieved to digital field, it is seen as the whole technology in which revolution technologies can communicate, analyze and enable these findings to transit from physical to digital and digital to physical by using them to maintain smart actions in the physical world [12]. Integration provided with the internet constitutes the foundations of industry 4.0. With this integration provided including technologies, businesses will be able to obtain flexible solutions, optimize production and gain advantages in the competitive environment, as well as making decisions. [6].

The necessity of three basic characteristics in order to use these technologies include the digital integration of engineering throughout horizontal integration, vertical integration and production system networks through all value chain [13]. Industry 4.0 technologies are presented in Figure 1.

Figure 1. Industry 4.0 Technologies

3.1. Internet of Things

Due to this new technological concept, named as internet of everything, machines and devices have the ability to communicate with each other over-the-net [14]. When considered within the internet of things and services, and functionality in businesses, this communication helps factories to become smart environment by creating networks that include all production processes [6].

Internet of things provides three basic opportunities. First of them is to obtain data regarding consumer effect with new contextual data sources, which reflect things around, and by combining several data with smart analytics. The second opportunity is to make solving problems possible by increasing creativity with both end-to-end automation and association of human-machine with these devices which are in communication and coordination in a way that increases effectiveness and efficiency. The last one is to enable new interactive things to emerge in order to provide value for humanity [15].

3.2. Cyber Physical Systems

With exponential information processing that enables getting stronger, new interrelated technologic systems to increase in transmission, storage capacity and also continuous progress in the information and communication technologies are some of the cyber physical systems features. In other words, communication between physical world and cyber worlds and all of the structures that include integration are defined as cyber-physical systems [16]. The most important feature of cyber-physical systems is defined as enabling nimble and dynamic needs of production, taking efficiency to higher degrees besides effectiveness of all industry. Cyber physical systems refer to the integration of physical processes and calculation.

3.3. Horizontal and Vertical Integration

Vertical integration requires cross connections and digitalization at different hierarchical levels in business units within the organization. Hence, vertical integration initially renders transition to smart factories, which are small and different in numbers, have efficiency at an acceptable level, make production possible to adapt to more demand, have high flexibility, and possible [13].

By means of Industry 4.0, in which vertical and horizontal integration are realized, it is possible to quickly answer to changes and problems in production processes, smoothing of production especially to consumer and customized goods, increase resource productivity, obtain optimization in global supply chain. In addition, it is possible for businesses to reach more flexible structure and needed changes that can be met with simple interface updates.

3.4. Big Data and Data Analytics

To mention advantages which are provided to today's business world from Industry 4.0 technologies within the context of big data, data can be produced with the help of machines and devices and recorded within the cloud-based systems [17]. Business managers or consumers can easily acquire this data when there is a need for it. It is foreseen that the size of data on the network will refer more than just purchasing product in the upcoming years.

Analysis methods that benefit from big data groups, finding new application area in production itself, not only increase the quality of production but also make possible maintenance and repair of equipment to be made more easily with energy conversion.

3.5. Cloud Computing

When considered with the production, cloud computing is argued as a production method that is binding shared, distributed production resources to a line with a sharing logic by increasing productivity, creating cyber-physical production lines that decrease production costs and contribute to providing optimum resource [18]. This technology is seen as the most important technology that will provide the occurrence of smart factory networks that realize the transformation of traditional business model for manufacturing industry, have influence on the transformation state of business strategy to coherent form, and support the occurrence of an important coordination [19].

3.6. Artificial Intelligence

Artificial Intelligence is defined as a cognitive science that has wide research practices in the fields like processing display, processing natural language, and learning robotic machine [20]. What is expected from artificial intelligence is creating a rational result regarding the issue as well as presenting solutions to possible problems, making instant decisions as if being a human by having a mind at human level [5]. In the production areas, artificial intelligence takes smart production to high level in many ways. Advanced analytical tools in machines can analyze the data collected from sensors for monitoring and estimating engine troubles, overloads or other problems. This provides a predictive maintenance opportunity that helps to prevent stopping times, caused by unpredicted breakdowns [21].

3.7. Additive Manufacturing

Additive manufacturing, named as “3D print” in the literature, is defined as a system that creates a physical object by printing layer on layer from a three dimensional digital drawing or model. It is an exact opposite application of subtractive manufacturing in which layers are removed by pieces until desired form of a material is finally reached [15]. This technology that decreases substantially production costs will create an important awareness in terms of production and innovation for developing countries. This technology will make a big contribution to the transformation of creative ideas and designs into real models, last products and prototypes by bringing changes and innovations that break ground in the production technologies [7].

3.8. Augmented Reality

Augmented reality contributes to the integration of information, revealed by additional computers into the real world. Most of the latest augmented reality practices are the adaptation of computer graphic users to their environment. Augmented reality will have application areas in activities such as assembly and disassembly, information management, education, examination, and assignment. This technology enables accessing information at another level and type of use by increasing virtual sense of information [22].

3.9. Cyber Security

Cyber security is defined as keeping under control of data security. Devices are being active on the net means that they remain unprotected in a danger environment. Security that cannot be provided can result in data loss and inability to provide information security. Information security, holding the control matters significantly within the context of technical, legal and human-centred security in response to threats that can emerge during activities such as creation, processing, storage and even destruction of information in the organization in which it is produced or out of organization. The purpose of cyber security systems is to ensure the security of companies, as well as to ensure that physical communication is carried out in the most appropriate environment.

3.10. Smart Factories and Smart Production

Increasing demands to customized goods and services and frequent market fluctuations cause disruptive difficulties to provide management and control of production processes. The integration of Industry 4.0 technologies to vertical integration transforms traditional factory into more flexible and reconfigurable production system, in other words, smart production facility [13]. In order to prevent possible disruptions, smart factories are defined as new smart manufacturing systems that cover regulation in data management and practice-based future advanced manufacturing technology. The aim of smart factories is to put into production ecosystems that produce goods that have high production efficiency, do not sacrifice quality and at the same time have low cost and resource consumption, have an environment perception in which industrial devices act together with network technology that can be reached from everywhere. [23] state that people, machines and resources keep in touch with each other like a social wax in smart factories and they know how they should be used in detail. They argue that they actively support production process of these systems [6].

Kang et al. argue that smart production, accepted as a new paradigm in the fourth industrial revolution, accepted as the last revolution in the manufacturing industry is the latest technology that is to support making real-time effective and right decisions by means of convergence with the introduction of various data processing technologies and existing production technologies [24]. In their studies, Frank et al. analysed the smart production in six main dimensions. These are vertical integration, virtualization, automation, traceability, flexibility, and energy management.

3.11. *Why Smart Production?*

The term of smart production is especially used to refer to digital production network [6]. In order to produce more than one small party goods in smart production, more different types of resources can be together in the system. While switching between different types of goods, necessary resources and connecting way to these resources can be restructured automatically and online. There is a structure in which machines have interactive high speed connections with products, information system and working group [13]. In their studies regarding how Industry 4.0 technologies affect production efficiency in organization, [25] state that these systems and technologies connect with each other by using standard internet-based protocols. In addition to that, they argue that they can restructure themselves by detecting errors; they can collect data from machines by sensors and internet connectivity, and provide faster and more flexible and efficient processes in order to produce high-qualified goods with lower costs.

In smart production systems, the technologies and services of internet of things and cloud systems work relationally and conjointly with physical systems. In other words, physical things and virtual structure are built one within the other. Within the self-organization of system with connections, provided in this structure, it enables physical things to make connections and contact with each other and to be self-organized. Smart structures, integrated into smart production can produce huge data. This obtained data can be transferred with possessed virtual network, big data can be retrieved from system when needed with cloud computing and they can be used as an important data during making decisions [13]. In smart production, products find the way which is necessary throughout production processes by themselves and easily defined.

In their studies, [26] state that a production process will be possessed with 30% faster, 25% more efficient transformation to smart production in production systems with the use of Industry 4.0

technologies. In their studies, [27] state that 82% of organizations that apply smart production technologies production processes have continuous efficiency increase in the production. 49% of them encounters fewer product defect and customer satisfaction of 45% of them has developed in a positive way.

4. Conclusion

Today, changes, arisen with the effect of uncontrollable environmental factors force organizations, in which people are, to keep up with change with every new technology wave since pre-agricultural times and affect organization in this way. Business environment that experiences breaking point with the first Industrial revolution, increase in the demand with industrial production, increasing population and urbanization, trigger the change trend and this provides several innovations to be experienced at certain time from past to present.

Fourth industrial revolution makes the line between human and technology less visible by increasing the interaction of physical and digital worlds. The effect of these changes on working types of people and value, produced by organizations will cover all economies and industries and the future of business will be redesigned. Several organizations in the developed countries around the world prefer countries, in which labour force is cheap, for many operations towards production as a force of competitive price policies and in order to keep production costs at low level. Consumer in the position target group prefers to diversification of supply chains for the protection of brand image with the delivery risks, which can be arisen because of the singularity of supply chain. Industry 4.0 technologies will be able to enable, even partially, some production operations in their countries by affecting positively labour costs of developed countries [1]. From this point of view, developing countries like Turkey should not ignore the face-off possibility with the risk of losing the cheap labour force advantage. That developing countries take position as opposed to the advantages of developed countries, provided by the integration of Industry 4.0 technologies and smart production technologies, making production processes smart, and at the same time applying these technologies in practice by using Industry 4.0 technologies that enable them to use production processes in a proper and competitive way, reaching thus great importance. The realization of a coordinated transformation with industrial enterprises in our country, when considered factors like cost and efficiency expectations of digitalization in this period during which several uncertain ties were experienced and countries preferred more protectionist foreign

trade policies in the international trade because of fight against epidemic; the importance of Industry 4.0 technologies and smart production is not only understood but also the use of them in the field has become an important issue.

Companies put up a fight to decrease the production costs, increase production efficiency, support industrial growth, change the structure of labour force and as a result of these; take the power of competition of itself and the area in which it exists to a higher level; create investment and marketing strategies in the issues like technological innovation, the employment of qualified worker that underlie the bases of Industry 4.0 [28]. It is pointed out in many studies that technologies such as cyber physical systems, internet of things, artificial intelligence, technologies of the Industry 4.0 provide advantage to organizations to understand the necessities in future.

The adaptation level of countries and companies to technological transformation that develops irrepressibly has the characteristics of guidance regarding their future position. Digital Transformation in Industry Platform, which supported by several organizations and business world organizations such as TUSIAD (Turkish Industrialists' and Businessmen's Association) in Ministry Of Science, Industry and Technology, Turkish Union of Chambers And Exchange Commodities, Aegean Region Chamber of Industry contribute, was established in order to support the transition of Turkey into Industry 4.0. In addition to these organizations, by increasing collaborations between business world and universities within the scientific research the encouragement of business world regarding these technologies will contribute to applications by increasing the familiarity of technologies. Compared to past years, many studies regarding Industry 4.0 technologies are made by academics in our country. Most studies were made as a literature study. These studies will be made in the direction of empirical studies to add new values to literature, and they will also contribute positively to development and transformation as a result of tangible data in the business world.

References

- [1]. Gerekli, İ., (2020). Effect of Industry 4.0 Technologies on Labor Efficiency and Business Performance an Application in Textile Sector, *Kahramanmaraş Institute of Social Sciences Department Of Business Administration, Production Management Department, Kahramanmaraş Sutcu Imam University, Turkey, Phd Thesis, 1-106*.
- [2]. Barreto, L., Amaral, A., & Pereira, T. (2017). Industry 4.0 implications in logistics: an overview. *Procedia Manufacturing, 13*, 1245-1252.
- [3]. Saatçioğlu, Ö. Y., Tuğdemir, G. K., & Özispa, N. (2018). Endüstri 4.0 ve lojistik sektörüne yansımalarının örnek olay kapsamında değerlendirilmesi. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 23*(Endüstri 4.0 ve Örgütsel Değişim Özel Sayısı), 1675-1696.
- [4]. Pamuk, N. S., & Soysal, M. (2018). A research on new industrial revolution industry 4.0. *Verimlilik Dergisi, 1*, 41-66.
- [5]. Özdoğan, O. (2017). *Endüstri 4.0: dördüncü sanayi devrimi ve endüstriyel dönüşümün anahtarları*. Pusula.
- [6]. Kagermann, H., Wahlster, W., & Helbig, J. (2013). Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group. *Forschungsunion: Berlin, Germany*.
- [7]. Ebso, (2015). Those Who do not adopt to Industry 4.0 will lose, *Aegean Region Chamber of Industry Journal*.
- [8]. Drath, R., & Horch, A. (2014). Industrie 4.0: Hit or hype?[industry forum]. *IEEE industrial electronics magazine, 8*(2), 56-58.
- [9]. Mahiroğulları, A. (2005). Two Works Documenting the Abuse of Labor After the Industrial Revolution: Germinal ve Weavers, *Sociology Conferences, 32*, 41-53.
- [10]. Carr, N. (2009). The Big Switch: Rewiring the World, from Edison to Google. *Journal of Information Privacy & Security, 5*(2), 67.
- [11]. Von Tunzelmann, N. (2003). Historical coevolution of governance and technology in the industrial revolutions. *Structural Change and Economic Dynamics, 14*(4), 365-384.
- [12]. Gerekli, İ., & Bozkurt, Ö. Ü. İ. (2020). The Effect of the in the Acceptance of Mobile Advertisement on the Consumer Attitude (Sample of the Sütçü Imam University), *Smart Journal 6*(32), 812-824.
- [13]. Wang, S., Wan, J., Li, D., & Zhang, C. (2016). Implementing smart factory of industrie 4.0: an outlook. *International journal of distributed sensor networks, 12*(1), 3159805.
- [14]. Lee, I., & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons, 58*(4), 431-440.
- [15]. Schwab, K. (2016). *The Fourth Industrial Revolution: What it Means and How to Respond*. Cologny, Switzerland: World Economic Forum.

- [16]. Bartodziej, C. J. (2017). The concept industry 4.0. In *The concept industry 4.0* (pp. 27-50). Springer Gabler, Wiesbaden.
- [17]. Roblek, V., Meško, M., & Krapež, A. (2016). A complex view of industry 4.0. *Sage Open*, 6(2), 2158244016653987.
- [18]. Yildiz, A. (2018). Industry 4.0 and smart factories. *Sakarya University Journal of Science*, 22(2), 546-556.
- [19]. Xu, X. (2012). From cloud computing to cloud manufacturing. *Robotics and computer-integrated manufacturing*, 28(1), 75-86.
- [20]. Lee, J., Davari, H., Singh, J., & Pandhare, V. (2018). Industrial Artificial Intelligence for industry 4.0-based manufacturing systems. *Manufacturing letters*, 18, 20-23.
- [21]. Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics*, 210, 15-26.
- [22]. Akdil, K. Y., Ustundag, A., & Cevikcan, E. (2018). Maturity and readiness model for industry 4.0 strategy. In *Industry 4.0: Managing the digital transformation* (pp. 61-94). Springer, Cham.
- [23]. Wan, J., Cai, H., & Zhou, K. (2015, January). Industrie 4.0: enabling technologies. In *Proceedings of 2015 international conference on intelligent computing and internet of things* (pp. 135-140). IEEE.
- [24]. Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., ... & Do Noh, S. (2016). Smart manufacturing: Past research, present findings, and future directions. *International journal of precision engineering and manufacturing-green technology*, 3(1), 111-128.
- [25]. Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. *Boston Consulting Group*, 9(1), 54-89.
- [26]. Koren, R., & Palcic, I. (2015). The impact of technical and organisational innovation concepts on product characteristics. *Advances in Production Engineering & Management*, 10(1), 27.
- [27]. Shrouf, F., Ordieres, J., & Miragliotta, G. (2014, December). Smart factories in Industry 4.0: A review of the concept and of energy management approached in production based on the Internet of Things paradigm. In *2014 IEEE international conference on industrial engineering and engineering management* (pp. 697-701). IEEE.
- [28]. Çelik, T. Z. Endüstri 4.0 İle Firmaların Rekabet Stratejileri Seçimleri Ve Firma Büyüklüğü Arasındaki İlişki: Gaziantep Makine Halisi Üreticileri Örneği. *Gaziantep Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 2(1), 1-14.