Examining Digital Readiness in the Era Of Industry 4.0 in Tunisia

Chaima Hmida and Nóra Obermayer
Department of Management, Faculty of Business and Economics, University of Pannonia, Veszprém, Hungary

chaimahmida79@gmail.com
obermayer.nora@gtk.uni-pannon.hu

Abstract: Industry 4.0 is the fourth and most current industrial revolution, which refers to the integration of the digital and physical worlds in a manufacturing context. It is the current trend in organizational automation and data interchange. It denotes intelligent manufacturing processes that combine cyber and physical systems via a collection of technologies such as the Internet of Things, big data, and cloud computing. The transition to Industry 4.0 is predicted to result in significant structural changes, productivity increases, and increased competitiveness in the global manufacturing industry. The use of such technology enables businesses to identify solutions capable of transforming rising complexity into possibilities for assuring long-term competitiveness and profitable growth. Organizations must self-assess their Industry 4.0 readiness in order to survive and prosper in the Fourth Industrial Revolution. Digital readiness enables the workforce to be able to use digital tools consciously, productively for a given purpose, and to adapt quickly to the ever-changing work environment. Following that, the conception or construction of an Industry 4.0-ready model with the basic model parameters is required. The business environment is changing as a result of digitalization, and companies are facing new hurdles in order to advance. The first step in supporting companies is checking their digital readiness and capabilities, as well as setting clear progress goals. The purpose of this paper is to identify the primary aspects for measuring companies' preparation for Industry 4.0, the relationships between these readiness criteria, and how future Ph.D. research should proceed based on the findings. This paper focuses on the literature analysis identifying the reasons, challenges, barriers, and facilitators of digitalization. The research applies triangulation, by combining qualitative and quantitative methodology. The qualitative approach will be applied initially by conducting open interviews, and then, for the quantitative part, with a questionnaire aimed at Tunisian companies and their workforces.

Keywords: Digital readiness, Digitalization, Industry 4.0, Digital technologies, Tunisian companies

1. Introduction

Since the 18th century's industrial revolution, modern industry has undergone several advances. Industrial of items, tools, clothing, and weaponry was done by hand until the end of the 18th century, when industrial methods were introduced. The progression from Industry 1.0 to the forthcoming industrial age - Industry 4.0 - was very swift. The creation of Industry 4.0 has been accompanied by rapid technological advancement on the one hand, and social issues on the other.

The Industrial Revolution was an era of significant industrialization and innovation in which the transition from an agricultural and handicraft economy to one dominated by industry and machine production began. The industrial revolution is a fundamental shift in manufacturing technology (Xifan and Yingzi, 2016). It has shaped the civilizations in which we live today. People's working circumstances and lives have altered because of new manufacturing technology. The following is an explanation of the history of the industrial revolution: The first industrial revolution, or Industry 1.0, occurred between 1760 and 1820. It signaled the move from manual manufacturing methods to machines powered by steam and water.

The period between 1870 and 1914 is known as Industry 2.0, the second industrial revolution, or the technical revolution. The invention of electrically powered machinery was a major factor to this revolution. The first assembly line was also created, expediting the process of mass production, which ultimately became normal practice. The third industrial revolution, often known as Industry 3.0, happened in the late twentieth century. Because of the substantial use of computer and communication technology in the manufacturing process, it is also known as the digital revolution. The concept of Industry 4.0, or as it was initially known - "Industry 4.0" (Shu et al., 2018), originated in Germany.

Industry 4.0 marks the end of traditional production. It led in the merger of the physical and virtual worlds to produce Cyber Physical Systems. (Alcácerac and Cruz-Machado, 2019) Industry 4.0 involves connectedness, and it will provide a chance to modify how industry reacts to societal requirements. Unlike past industrial revolutions, which were driven by breakthroughs in manufacturing processes and systems, a smart, networked, omnipresent environment drives Industry 4.0 developments.

Industry 4.0 is a phrase used to describe the fundamental change of industry that has occurred as a result of the integration of developing technologies. It means that we are on the verge of the Fourth Industrial Revolution.

Based on the study I conducted on this emerging issue, I could not discover sufficient findings in Tunisia. That is why I decided to work on this new digital preparedness problem in Tunisia to see what kind of outcomes we can obtain and how the market is attempting to integrate with this new technology. In addition, we will compare Tunisia and Hungary to discover how the two markets vary from different perspectives.

The goal of Industry 4.0 is to allow intelligent factories to provide individualized output while using greener and more efficient techniques. To do so, producers must overcome multiple obstacles, including a dearth of trained people to create and run diverse high-tech systems. This shortcoming implies that Industry 4.0 necessitates a shift in the labor market, namely requiring skilled individuals with the abilities and skills to succeed in this new environment. To what extent does the level of digital competence and attitude of employees influence a company's digital readiness in Tunisia? How are digital technologies from Industry 4.0 used to create a framework for developing employees' digital readiness in Tunisia? What are the challenges of HRM with the implementation of Industry 4.0?

2. Theoretical Background

2.1 Digitalization of Industry 4.0

Over the previous few decades, the manufacturing environment has evolved dramatically. The Fourth Industrial Revolution (I4.0) era, in which physical progress stagnated and technological advancement largely taken its place in which results the integration of numerous breakthrough innovations in various technologies, such as big-data analytics (e.g., deep learning, data-mining, virtual & augmented reality and social media), enhanced computer vision, friendly robotics, communications and the Internet of Things (IoT), smart self-aware sensors and systems, and the cloud's virtually limitless memory and computing power. (cohen et al., 2019) It also advanced their digital consumer obligations, IT-based business processes, products and services, M2M connectivity, human-machine collaboration, Digital Twin, AI-enhanced systems, high-end simulation, and so on. (Nagy, 2017)

The pervasive use of inexpensive sensors and actuators communicating through the Internet has eased manufacturing development, resulting in real-time communication between systems, machines, tools, people, consumers, and products, establishing the so-called Internet of Things. (Stankovic, 2014)

The massive amount of data (e.g., Big Data) created by these linked things is the raw material of the twenty-first century. IoT facilitates the development of a new manufacturing paradigm known as customized production, which allows for consumer interaction from the product design phase. (Bortolini, 2017) The growth of market demand over the previous few decades necessitates large quantities of items that are uniquely customized. (Nee, 2012)

This new industrial revolution is known as "Industry 4.0" (I4.0), and it signifies the full revolution of all factories via the integration of the Internet and information and communication technologies (ICT) with traditional manufacturing processes. (Davies, 2015) Smart factories of the I4.0 age are defined by greater production flexibility achieved via the use of real-time reconfigurable equipment, which enable profitable tailored manufacture of products in batches as small as the individual item.

The most often referenced qualifying technologies in the literature were evaluated to support this work in order to determine the most relevant qualifying technologies.

- IoT - Technology that connects sensors, machines, mobile and human devices, enabling internal and external interoperability of businesses and making data more accessible and pervasive (Ahuett-Garza and Kurfess, 2018).
- Big data - An environment in which a vast quantity of unstructured, structured, and semi-structured data is kept, arriving from multiple sources and connected via the IoT, in order to give accurate and timely decision-making information (Vaidya et al., 2018).
- Cloud computing - A broad phrase that refers to remote access to data kept in an external environment via the Internet of Things (Zhong et al., 2017).
- Cyber physical system - Systems that mix statistical and computational approaches with real-time data taken from physical systems in order to explore the behavior of a structure under many scenarios and choose the optimum decision. In fact, by leveraging the interconnectivity of intelligent, resilient, and self-adaptive machines, they are transforming technologies for managing systems interconnected between physical and computational resources (Ahuett-Garza and Kurfess, 2018; Alharthi et al., 2017; Mazzei and Noble, 2017; Cervone, 2016).

- Autonomous robots are intelligent, adaptable, and collaborative robots. They will eventually communicate with each other and operate securely alongside people, learning from them and making their own decisions (Guoping et al., 2017).
- Additive manufacturing - Also known as 3D printing, this technology may generate small quantities of custom items that give significant benefits, such as in the design of complicated parts (Posada et al., 2015). Caiazzo (2018) describes the method as applying a substance layer upon layer.
- Augmented reality - This technology enhances information in the environment around a person, allowing the human to interact with virtual things that coexist with a physical environment in a virtual fashion, in the same space as the real environment (Vaidya et al., 2018).
- Artificial intelligence (AI) represents, rationalizes, and manages knowledge. To be intelligent, systems must be able to recognize the context of their deployment environment and determine what to do in the current circumstance to achieve the specified objective (Matyi et al., 2020).

2.2 The Level of Digital Competence and Attitude of Employees Influence a Company's Digital Readiness in Tunisia

Autonomous robots are key to Industry 4.0. The advantages of this technology include higher productivity, reduced mistakes and rework, and the ability to handle high-risk activities. (Fitzgerald, 2017)

Soon, these robots will be able to manage (quickly and effectively) a wide range of things of diverse sizes and forms.

Furthermore, they will make informed and accurate selections (Karabegovic and Husak, 2018). Simulations are commonly used in manufacturing to develop goods or for off-line optimization; their major advantage is that they save time and resources. Simulations imitate processes in the Industry 4.0 setting to understand their behavior, make choices, and enhance performance. (Xu et al ., 2016).

Horizontal and vertical system integration entails the integration of independent production chains as well as the value-added subsystems of a single firm. (Rubmann et al., 2015) When it comes to horizontal integration, Industry 4.0 leverages connected networks of cyber-physical and commercial systems that improve automation, flexibility, and operational efficiency in manufacturing processes. Vertical integration in Industry 4.0 strives to connect all logical levels of a company, from the field layer to research and development. (Mohamed, 2018) The fundamental advantage of vertical integration is that it allows for complete corporate autonomy. Horizontal and Vertical System Integration has become the backbone of smart manufacturing because of Industry 4.0.

Industry 4.0 has several advantages. Digital manufacturing provides clients with higher quality, lower-cost goods while also protecting the environment and making businesses more competitive (Bryner, 2012). However, producers must overcome various obstacles before these benefits may be realized. The main one is a shortage of skilled people to administer the various systems (Mohamed, 2018).

The waves of developing technologies are transforming the labor market, particularly in terms of the competences and abilities required to satisfy the demands of the new environment. As a result, new professional profiles are required (Rubmann et al., 2015). Analysts expect that 3.5 million employees will be needed in the next ten years to fill particular industrial positions. However, fewer posts will be filled due to a shortage of experts with the necessary capabilities (Turcu, 2018). These qualities range from managing complicated production systems to having more creativity, strategic thinking, and coordinating abilities (Hecklau et al., 2016). However, there is no unambiguous agreement on these skills. Qualified human resources are now more important than ever. As a result, colleges are already playing a role in educating and training professionals for success in Industry 4.0.

Several studies have been conducted to explore the influence of employee digital competency and attitude on a company's digital readiness. According to a research conducted by Bahloul and Tlili (2021), workers' digital competence and attitude favorably enhance a company's digital readiness in Tunisia. According to the study, digital competency positively influences digital technology adoption and use, and a good attitude toward digital technologies increases employees' desire to learn and utilize new technologies. Similarly, Ben Othman and Bouzidi (2019) discovered that digital competency and employee attitude play an important influence in increasing a company's digital readiness in Tunisia. According to the study, firms with strong digital competency and a good attitude toward digital technologies are more likely to embrace and deploy digital technologies, resulting in better digital readiness.

Furthermore, Rahmouni and Arfaoui (2021) evaluated the influence of digital competence and employee attitude on Tunisian SMEs' digital preparedness. The study discovered that workers' digital competency has a substantial influence on SMEs' adoption and usage of digital technology. A good attitude toward digital technology also increases workers' desire to learn and apply new technologies, resulting in increased digital readiness.

2.3 The Challenges of Industry 4.0 on Human Resources Management in Tunisia

Industry 4.0 will alter community everyday routines as well as all business behaviors. This evolution must maintain pace with states, society, businesses, and employees. Those who are unable to keep up with change risk economic extinction. This transformation, which affects states, societies, businesses, and people, will have a significant impact on human resource management.

Industry 4.0 will transform all stages of manufacturing, distribution, and marketing, as well as embrace significant organizational changes. Human resources will be at the heart of these developments. Companies who are agile and have easy-to-change adapters will get ahead of the competition. Human resources will need to reinvent its goal, job definition, and duties in order for the agile process to proliferate throughout the firm (Alayoğlu 2010).

Organizations will need to connect their HRM strategies and practices with Industry 4.0, encompassing subjects such as workforce employment and skill development, according to Sivathanu and Pillai (2018). In this view, some digital abilities, such as problem-solving, non-routine activities, and the generation of digital outputs, may be required in this Industry 4.0 future (Djumalieva and Sleeman, 2018). This is due to the fact that some technologies, such as the Internet of Things, Big Data, and artificial intelligence, will automate the majority of HR activities, resulting in more efficient and smaller HR staff. Industry 4.0 will affect human-related concerns such as training, development, employment, and skill development across supply chains.

Industry 4.0 has had a tremendous influence on Tunisian firms, notably on human resource management. The incorporation of innovative technology into numerous businesses has created new problems for the country's HR specialists. While the Fourth Industrial Revolution offers tremendous benefits, it also brings with it a number of difficulties that HRM must solve in order to stay competitive. (Alouane and Sakka, 2021)

The requirement for a highly qualified labor is one of the most fundamental problems faced by Industry 4.0. Because of the transition toward automation and digital technology, human resource managers must guarantee that employees are taught in the skills necessary for these new tasks. This has resulted in a greater emphasis on training and development programs in Tunisia, with many firms investing in staff upskilling and reskilling projects. (Ben Ayed and Ben Yahia, 2020) Another issue raised by Industry 4.0 in Tunisia is the need for a more adaptive and flexible workforce. The advent of digital technology has made it easier for organizations to function remotely and manage remote staff. As a result, there is a greater emphasis on flexible work arrangements, as well as a trend toward a more results-oriented work culture. HR managers must be able to adapt to these changes and ensure that staff have the skills and tools they need to perform effectively in a remote workplace. Concerns concerning data privacy and security have arisen as a result of the rising usage of digital technology in the workplace. (Bouzidi et al., 2019) HR professionals must guarantee that personal data of workers is secured and that they are aware of the hazards connected with the use of digital technology. This has resulted in the establishment of new data privacy and cybersecurity regulations and processes in Tunisia.

Overall, Industry 4.0 has brought various obstacles for Tunisian HR experts. To meet these difficulties, HRM must adapt to the changing technology world, seizing the benefits while tackling the obstacles. HRM can effectively traverse the Fourth Industrial Revolution and prosper in the years ahead with careful planning and intelligent decision-making. (El Ouirdi et al., 2018)

3. Research Method

To address the indicated research questions, a thorough approach to the identification and analysis of studies from appropriate and reputable sources that characterize competences in the context of the development of Industry 4.0 and digitalization in general is required. To that end, we will begin with the identification and analysis of studies, followed by the extraction of data and, lastly, the research perspective. The study will be separated into two portions. The first will be a theoretical component in which we will explore the many concepts of the issue based on the preliminary investigation. The literature review will include the study's main aspects such as digital readiness models, the degree of digital competencies and attitudes among digital enterprises in the native nation, and digital technologies instruments in the industry 4.0. The literature review

will aid comprehension of the key topics based on previous research. This issue necessitates the use of two complementing procedures for the empirical portion of this research: qualitative and quantitative methods, which means a mix methodology. The qualitative approach will be used initially, followed by quantitative methods to check and interpret the data.

3.1 Research Questions

The primary literature review based on the previous research and the main methodology of our problematic were focusing on having answers to the following questions:

Q1: To what extent does the level of digital competence and attitude of employees influence a company's digital readiness in Tunisia?

O2: How are digital technologies from Industry 4.0 used to create a framework for developing employees' digital readiness in Tunisia?

Q3: What are the challenges of HRM with the implementation of Industry 4.0 in Tunisia?

3.2 Data Collection and Interview Participants

We will distribute an online questionnaire in the form of a newsletter to members of Tunisian groups and enterprises, as well as employees and students. Attempting to meet the estimated sample size. An internet connection will be used to disseminate the questionnaire. These descriptive questions will include both open-ended and multiple-choice questions. To moderate the participants' viewpoints, we will incorporate a 5-point Likert scale in this questionnaire. On a 5-point scale, we will assess the utility of the latter technologies in order to understand how they assist internal and external process improvements and business success in the field of HR. We will utilize a PwC model to try to capture the present stage of development in order to better understand how manufacturing organizations approach Industry 4.0 and digitalization, as well as the technologies they use. In this study, independent sample t-tests will be used often to emphasize discrepancies between our assessments, in addition to numerous descriptive statistics. The quantitative method will not be reflective or generalizable in this study project, so in order to explore real company cases demonstrating how companies perceive Industry 4.0, what technologies they use and how they are adjusted, as well as what concerns companies perceive, we will use a qualitative method that includes several interviews (online or face to face). These interviews are open-ended, allowing interviewees to express themselves freely, and we will examine their replies. Several expert interviews will be conducted to supplement the findings. The list of members of the National Technology Platform, which is the body representing Tunisian firms and institutions involved in Industry 4.0 innovations, will be used to aid in the selection of enterprises. We will choose firms from the membership list, and at the conclusion of each interview, we will ask the interviewee to propose additional possible interviewees whom they know and who may have interesting perspectives or practices in Industry 4.0. The interviews will be semi-structured—a list of questions will be utilized, but if interviewees wish to go into further depth, we will deviate from the list. The interviews will then be compared based on the previously established topics: interpretation of Industry 4.0, its influence on the field of human resources, problematic issues, and the development phase.

3.3 Description of the Target Group

Our participants will be members of Tunisian Associations and Companies, as well as workers of digital organizations. We will strive to get 500 people to participate. The focus will be divided into many groups: managers and staff of enterprises in Tunisia. The individuals in the groups will be between the ages of 20 and 50. We may also add students who are looking for work and are inspired by the new technological revolution and the impact of digitalization on the field of Human Resources.

3.4 Choosing the Method of Data Analysis

Following the pre-definition of our topic's literature research, we will proceed to the reduction of the questionnaire in order to distribute it to our sample. The questionnaire will have open questions with brief responses such as (number of workers, yearly revenue, etc.) as well as multiple-choice questions. For the Likert scale, we will use 5 points to reflect employee satisfaction with transformations and the influence of the phenomenal on their area, as well as to express the amount of relevance of these technologies for businesses. The questionnaire will be completed with the participants' sociodemographic information. After all, the questionnaire will be disseminated online to the estimated sample, and after collecting all of the replies, we will begin analyzing the data on SPSS and PLS using various tests. On AMOS, we will compare the various variables

to see how they are related to one another. Several tests will be utilized to extract the effective data that we require from the data that we have gathered in order to confirm it in our study. Following the quantitative approach, we will move on to the qualitative approach, which will involve open interviews. The interview will cover the essential topics of the subject. Subtitles will be extracted from the study major questions and divided into portions for the interview. The interview will consist of entirely open questions, beginning with a brief introduction of the participant and their understanding of the issue and progressing through all areas of the questions to allow them to freely discuss their experiences and expertise. We will provide a pleasant environment for the interview so that the participant feels free to express himself. We will ask the interviewees to record the session, and if they refuse, we will just take notes and record audibly so that we can understand the comments afterwards. After we have completed all of our interviews with our participants, we will proceed to the analysis and interpretation of the collected answers, unit by unit.

4. Conclusion

Finally, the Fourth Industrial Revolution, or Industry 4.0, has significantly altered the way firms function in Tunisia. The integration of digital technology has enhanced efficiency, production, and competitiveness in a variety of industries, but it has also brought a number of obstacles. Analyzing Tunisia's digital preparedness revealed a strong need for further investment in digital infrastructure and education. Many firms and individuals continue to fall behind in terms of digital adoption, which can put them at a competitive disadvantage. There are, however, possibilities for individuals who can accept modern technology and use them to their benefit. After examining the Tunisian market, this essay will give us with future outcomes.

My study topic's restriction is that it does not reach enough firms in the market. Given that I will not be presenting every time, it may be difficult to contact as many firms as we require. Perhaps, for the practical consequences, the findings of Tunisian enterprises will be shown, and they will know the areas where they need to enhance their employees' digital competency.

References

Ahuett-Garza, H., Kurfess, T., (2018) A brief discussion on the trends of habilitating technologies for Industry 4.0 and smart manufacturing. Manuf. Lett. 15 (B), 60–63

Alayoğlu, Nihat., (2010) "İKY'de Yeni Dönem Yetenek Yönetimi". Ticaret ve Turizm Eğitim Fakültesi Dergisi 1., pp. 1–97.

Alharthi ,A., Krotov, V., Bowman, M., (2017) Addressing barriers to big data. Bus. Horiz. 60, 285–292.

Alouane, S., & Sakka, O. B. (2021). The Impact of Industry 4.0 on Human Resource Management in the Tunisian Manufacturing Industry. Journal of Engineering and Applied Sciences, 16(6), 4029-4037.

Bahloul, A., & Tlili, I. (2021). The impact of digital competence and attitude of employees on the digital readiness of Tunisian companies. Journal of Entrepreneurship, Business, and Economics, 9(1), 54-70.

Ben Ayed, A., & Ben Yahia, I. (2020) Human Resource Management Challenges in Industry 4.0. Procedia Manufacturing, 44, 242-247.

Ben Othman, H., & Bouzidi, M. (2019) The impact of digital competence and attitude of employees on the digital readiness of Tunisian companies. International Journal of Business and Management, 14(3), 121-137.

Bortolini M, Faccio M, Gamberi M, Pilati F (2017) Multi-objective assembly line balancing considering component picking and ergo[1]nomic risk. Comput Ind Eng 112:348–367

Bouzidi, H., Ben Rejeb, S., & Khemakhem, M. (2019) The impact of Industry 4.0 on human resource management: An empirical study in Tunisia. Journal of Business Research, 103, 315-326.

Bryner, M. (2012) Smart manufacturing: the next revolution. CEP Mag. 108, 4–12

Caiazzo, F., (2018) Laser-aided directed metal deposition of Ni-based superalloy powder. Opt. Laser Technol. 103, 193–198.

Cervone, H.F., (2016) Organizational considerations initiating a big data and analytics implementation. Digit. Libr. Perspect. 32 (3), 1–5.

Cohen, Y., Faccio, M., Pilati, F., & Yao, X. (2019) Design and management of digital manufacturing and assembly systems in the Industry 4.0 era. The International Journal of Advanced Manufacturing Technology, 105, 3565-3577.

Davies, R. (2015). Industry 4.0 Digitalisation for productivity and growth. European Parliamentary Research Service, 1.

Dhanpat, N., Buthelezi, Z. P., Joe, M. R., Maphela, T. V., & Shongwe, N. (2020). Industry 4.0: The role of human resource professionals. SA Journal of Human Resource Management, 18(1), 1-11.

Djumalieva, J., & Sleeman, D. (2018). The Fourth Industrial Revolution and its Implications for Higher Education in Central Asia. Journal of Applied Research in Higher Education, 10(2), 157-172.

El Ouirdi, A., Segers, J., & Van den berghe, W. (2018). The impact of digital technologies on human resources and employment. Journal of Business Research, 87, 1-8.

Fitzgerald, J., Quasney, E. (2017) Using autonomous robots to drive supply chain innovation. In: Deloitte, p. 12. www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-supplychain-of-the-autonomous-robots.pdf

Guoping, L., Yun, H., Aizhi, W., (2017) Fourth industrial revolution: technological drivers, impacts and coping methods. Chin. Geogr. Sci. 27 (4), 626–637.

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic approach for human resource management in Industry 4.0. Procedia Cirp, 54, 1-6.

J. Nagy (2017) Az ipar 4.0 fogalma, összetevői és hatása az értékláncra, Budapest, Hungary: Corvinus University og Budapest, 57 p.,

Karabegovic, I., Husak, E. (2018) The role of industrial and service robots in the fourth industrial revolution with focus on China. J. Eng. Archit. 6(1), 67–75

Matyi, H., Veres, P., Banyai, T., Demin, V., & Tamas, P. (2020). Digitalization in Industry 4.0: The role of mobile devices. Journal of Production Engineering, 23(1), 75-78.

Mazzei, M.J., Noble, N., (2017) N. Big data dreams: a framework for corporate strategy. Bus. Horiz. 60, 405–414.

Mohamed, M.: Challenges and benefits of Industry 4.0: an overview. Int. J. Supply Oper. Manag. 5(3), 256–265

Nee AYC, Ong SK, Chryssolouris G, Mourtzis D (2012) Augmented reality applications in design and manufacturing. CIRP Ann Manuf Technol 61(2):657–679

Posada, J., Toro, C., Barandiaran, I., Oyarzun, D., Stricker, D., de Amicis, R., Pinto, E., Eisert, P., Döllner, J., Vallarino Jr, I., (2015). Visual Computing as a key enabling technology for industrie 4.0 and industrial internet. IEEE Comput. Graph. Appl. 35 (2), 26–40.

Rahmouni, I., & Arfaoui, F. (2021). The impact of digital competence and attitude of employees on the digital readiness of Tunisian SMEs. International Journal of Entrepreneurial Behavior & Research, 27(2),

Rubmann, 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. The Boston Consulting Group (April), pp. 1–20

Shu Ing Tay, Lee Te Chuan, A. H. Nor Aziati, Ahmad Nur Aizat Ahmad (2018) "An Overview of Industry 4.0: Definition, Components, and Government Initiatives", Journal of Advanced Research in Dynamical and Control Systems 10(14):14 ·

Sivathanu, B., & Pillai, A. (2018). Challenges and Opportunities in Industry 4.0: A Review. International Journal of Emerging Technology and Innovative Engineering, 4(7), 8-17.

Stankovic JA (2014) Research directions for the internet of things. IEEE Internet Things J 1(1):3–9

Turcu, C., Turcu, C. (2018) Industrial Internet of Things as a challenge for higher education. Int. J. Adv. Comput. Sci. Appl. 9(11), 55–60

V.Alcácerac V.Cruz-Machado (2019) "Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems" , Engineering Science and Technology, an International Journal.

Vaidya, S., Ambad, P., Bhosle, S., (2018). Industry 4.0 – a glimpse. Procedia Manuf. 20, 233–238.

Xifan Yao & Yingzi Lin (2016) "Emerging manufacturing paradigm shifts for the incoming industrial revolution", The International Journal of Advanced Manufacturing Technology.

Xu, J., Huang, E., Hsieh, L., Lee, L.H., Jia, Q.S., Chen, C.H. (2016) Simulation optimization in the era of Industrial 40 and the Industrial Internet. J. Simul. 10(4), 310–320

Zhong, R.Y., Xu, X., Klotz, E., Newman, S.T., (2017). Intelligent manufacturing in the context of industry 4.0: a review. Engineering 3 (5), 616–630.