Socio-technical perspectives in the Fourth Industrial Revolution - Analysing the three main visions: Industry 4.0, the socially sustainable factory of Operator 4.0 and Industry 5.0

Emanuele Gabriel Margherita[1], Alessio Maria Braccini[1]

[1] *University of Tuscia, Department of Economics Engineering Society and Organization – DEIM, Via del Paradiso, 47, 01100, Viterbo, VT, Italy*

Abstract

In this position paper, we discuss the socio-technical perspective of the Fourth Industrial Revolution. The fourth industrial revolution refers to the novel wave of advanced technologies – like Robotics, the Internet of Things, Big Data – that are adopted in manufacturing organisations. Scholars and practitioners have forecasted the fourth industrial revolution, and it is still underway. This situation allowed the proliferation of various visions in the fourth industrial revolution literature: Industry 4.0, the socially sustainable factory of Operator 4.0 and Industry 5.0. Through a literature review, we analyse the manifesto and pivotal papers of such visions in order to assess how they employ the socio-technical perspective. The results show that Industry 4.0 vision mainly considers the technical system. The vision of the socially sustainable factory of Operator 4.0 is an attempt to consider the social system in conjunction with the technical system. Then, Industry 5.0 vision is socio-technical in nature and also takes into consideration sustainability outcomes.

Keywords

Socio-technical theory, industry 4.0, industry 5.0, operator 4.0, socially sustainable factory, literature review

1. Introduction

Over the last years, the development of a new wave of advanced technologies – such as the Internet of things, Big Data analytics, Additive manufacturing - have attracted the interest of practitioners and scholars in several sectors of the smart city [1], citizen science [2], tourism [3] and manufacturing [4].

Within the manufacturing realm, such technologies usher the Fourth Industrial Revolution [4–6]. Several studies posit the extensive impact that such technologies have on the production processes and on business models of manufactures [7, 8]. These technologies make the production system more efficient and automated [9]. Thus, the fourth industrial revolution passes into the annals of history as a forecaster industrial revolution that is still underway [10]. Several studies confirm this progress status that is focused on the implementation issues and barriers of these technologies and the uncertain societal impacts of such technologies [11–13].

Since scholars and practitioners forecast the fourth industrial revolution, various visions have proliferated in literature over the years. Therefore, in this paper, we use the label of the fourth industrial revolution as an umbrella term to embrace all these visions (see Figure 1). The three main visions are Industry 4.0 [5], the socially sustainable factory of Operator 4.0 [14] and Industry 5.0 [15]. Each vision has a different manifesto embracing different technical and human factors that generate bewilderment in literature.

Proceedings of the 7th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2021), October 14-15, 2021
EMAIL: emargherita@unitus.it (A. 1)
ORCID: 0000-0001-5528-6817 (A. 1)

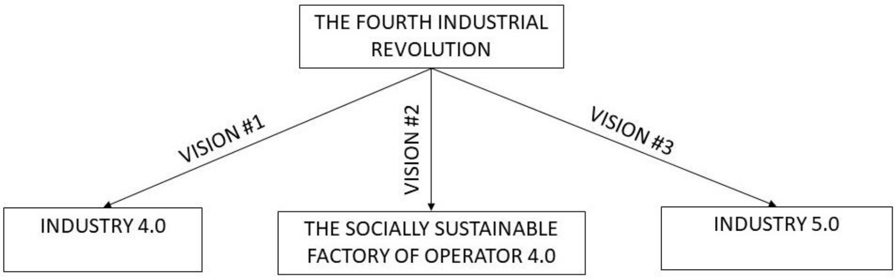

Figure 1 The visions of the fourth industrial revolution

This study aims to highlight the differences of human and technical factors among the three visions by employing the socio-technical theory [16]. The socio-technical theory considers the organisation composed of technical and social systems [17]. The joint optimisation of both systems allows the organisation to operate efficiently, leading to instrumental and human benefits [18]. In technical systems, the improvements concern better performance and achieved economic objectives, whereas the improvements in the social system concern enhanced job satisfaction and a higher quality of work-life balance. The socio-technical framework is conceptualised in Figure 2.

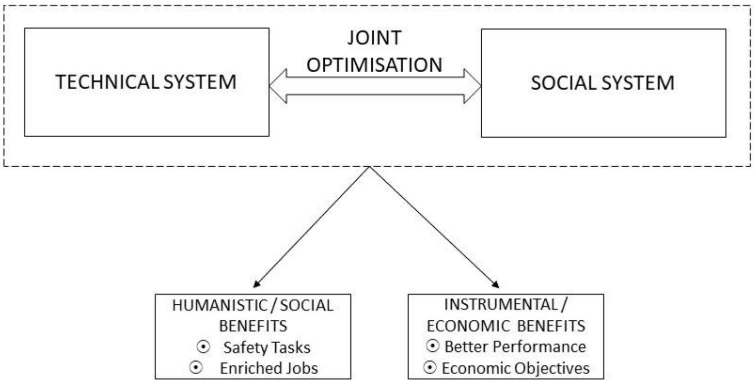

Figure 2 The socio-technical framework (based on [17]*)*

To this end, we conduct a literature review [19] in order to retrieve the manifesto and pivotal articles for each fourth industrial revolution vision. Then, we analyse such studies by using the socio-technical theory as a sensitive device. The study addresses the following research questions: " How do the three visions of the fourth industrial revolution embrace the socio-technical perspective?"

The study contributes to the socio-technical literature stream by showing the socio-technical perspective of the three visions in the fourth industrial revolution and their main differences.

The structure of the paper is as follows. We present the research design in Section 2. The Industry 4.0 vision follows in Section 3. Then, we debate the socially sustainable factory of Operator 4.0 and Industry 5.0 in Sections 4 and 5, respectively. We discuss the result of the review in section 6, and we conclude the article in section 7.

2. Methodology

We conducted a literature review on Scopus, Science Direct and Google Scholar in July 2021 [19]. We employed as keywords search: "Industry 4.0" AND "Industry 5.0" AND "Operator 4.0" AND "Fourth Industrial Revolution" refined by articles in English included in Business, Management and Accounting subject area. We aimed to detect and the manifesto and the pivotal articles of the three visions of the fourth industrial. We select those articles that discuss such visions in depth. They are literature reviews, conceptual papers or empirical papers. By reading the title and abstract, we extracted 40 articles. The authors thoroughly read the selected papers by selecting 20 papers, which we use for this article as a starting point of the research. One of the co-authors qualitative analysed the articles using as a sensitive the socio-technical theory, considering (1) how studies have enacted the presence of the social and the technical and (2) the relative outcomes. Then, the two authors held some joint meetings to discuss the results and, where required, make verification to reach a consensus [19].

3. Industry 4.0

In chronological order, Industry 4.0 (I40) is the first vision of the Fourth Industrial Revolution [5]. For this reason, this label is used as a synonym of the fourth industrial revolution, but in our study, we consider I40 as a sub-vision of this industrial phenomenon. The manifesto of I40 was encouraged by the German Government and was released in conjunction with the "Industrie 4.0" industrial plan [5]. I40 industrial plan aims to present the I40 technologies, the technological tenets of the revolution and the potential technological outcome on the production system [20]. In the same way, European and Asian governments and American associations launched their industrial plans to – named "Industria 4.0", "Industrial Internet of Things", "Smart Manufacturing", "Made in China 2025", and "Industrial Internet"- with similar principles and technologies of the German initiative [20].

Here below, we condense a brief description of the most important I40 technologies:

- Internet of things describes the operation in which physical products and machinery are equipped with sensors like Radio-Frequency Identification in order to capture, process, and communicate in real-time data to humans as well as other pieces of machinery. These technologies require sensors and actuators to acquire and communicate through a WIFI network.
- Big Data analytics refers to technologies allowing to analyse of a massive set of unstructured or semi-structured data, which is not possible to analyse by traditional data process methods due to their complexity. Data analytics aims to reveal patterns, trends, and associations, especially relating to human behaviour and interactions.
- Additive manufacturing is an "umbrella term" that includes different technologies, such as 3D printing, to produce high-quality real objects by adding material rather than mechanically removing or milling material from a solid block.
- Virtual Reality, Augmented Reality, and Hologram are advanced technologies that aim at designing products, operation planning, factory layout planning, system maintenance through specific hardware and software without using real materials.
- Cloud manufacturing is the cloud computing technology that is applied to the manufacturing area. Indeed, Cloud manufacturing is mainly employed for its ability to make the entire manufacturing.

The main two principles of the I40 revolution are vertical and horizontal integration. Vertical integration is internal to the organisation and describes the integration of several organisational units, including marketing, sales and technology development, by end-to-end digitally integrated technologies across different levels. Horizontal integration represents the digital information sharing that facilitates collaboration among partners within a value chain, including customers [18].

Thus, the potential integration of different I40 technologies lays the foundation for the development of cyber-physical systems. Such systems allow the automation of various manual and decision-making activities previously performed by the workers.

The adoption of I40 technologies allows improving the efficiency of the production process. The review revealed that such adoption reduced lead-time operations, increased output quantity and quality of productions. Furthermore, the automation of various hard muscular activities, previously performed by workers, delivers safer tasks and work environment for workers as a positive externality. However, at the same time, the I40 adoption opens for various social drawbacks. The extensive automation of the production process promises to disrupt various white and blue-collar job positions. Moreover, the lack of competencies possessed by the traditional manufacturing workers pushes the organisations to fire them to embrace the I40 paradigm and hire workers but more competence with these I40 technologies.

Therefore, applying the socio-technical framework to the I40 vision shows that this perspective is merely technocentric (see Figure 3). The main focus is related to the adoption and integration of various technologies to improve production efficiency.

Although the social system is not emphasised, we found some benefits that the technical systems deliver on the social systems related to safer tasks. Such outcomes are coupled, however, with social drawbacks related to the job disruption. illustrates the socio-technical perspective of I40.

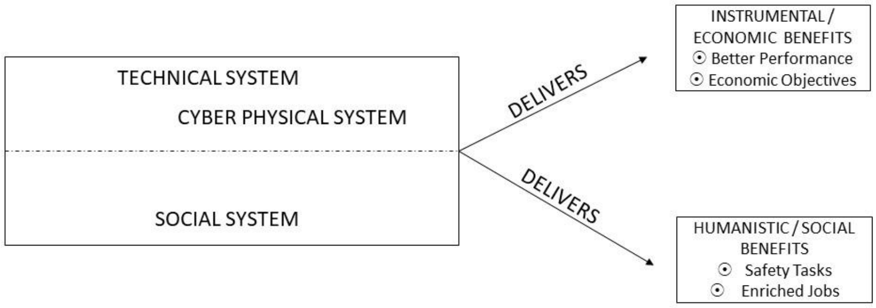

Figure 3 The Socio-technical perspective in Industry 4.0

4. The socially sustainable factory of Operator 4.0

The socially sustainable factory of Operator 4.0 (OP40) is the perspective of the fourth industrial revolution by Romero et al. 2016 [14]. This is an attempt to include human agency, particularly the workers operating along the assembly line, within the I40 production system [14]. Romero et al. 2016 wanted to rebut the I40 paradigm illustrating a socially sustainable factory where workers can cooperate with I40 technologies. Such workers are named "Operator 4.0", and they are defined as: a smart and skilled operator who performs not only cooperative work with robots but also work aided by machines"[21]. The technologies of the socially sustainable factory are I40 technologies that allow corporations with human agency. We found as new technologies the smart exoskeleton and the cobot. The smart exoskeleton is a wearable mobile machine supporting limb movement with increased strength and endurance through electric motors, pneumatics, and lever. Cobots are robots designed to collaborate with humans in safety. Cobots perform various hard muscular, repetitive, and non-ergonomic activities related to the movement and manipulations of objects faster than workers. We also found an increasing interest for the virtual and augmented reality that can help OP40 activities by providing visual aid through smart glasses or tablets.

The main contribution of the OP40 vision is a proposed "visionary" typology of the potential corporations between workers and technologies [14, 21]:

- The super-strength operator is an OP40 that conducts manual tasks equipped with a smart exoskeleton
- The smarter operator is an OP40 in charge of using I40 technologies with an intelligent personal assistant that facilitates the interaction with the I40 technology interfaces and information systems.
- Augmented and virtual operators are OP40s that perform mental, manual and maintenance tasks with augmented reality or virtual reality that provides visual guidance for their tasks and reduces mental and physical effort.
- The collaborative operator works with I40 technologies along the assembly line—such as cobots of robotised arms—to maintain constant and efficient organisation's production.
- The analytical operator is the OP40 that examines Big Data extracted from I40 technologies. This operator is in charge of predicting and preventing potential critical events along the assembly line, such as the breaks of machinery pieces or lack of lubrication of the conveyor belt.

Beyond this typology, the literature is devoted to the development of anthropocentric production or human-centric cyber-physical systems, namely manufacturing production systems that include OP40 in the design of the production systems. Nevertheless, the focus remains strictly technical without imposing OP40 competence and skills that remain an open question.

With regards to the outcome of the socially sustainable factory adoption, we found that I40 technologies can support the reduction of mental and physical stress [22] of the OP40 that, in turn, can conduct a more efficient production process. OP40 conducts activities quickly and addresses various problematic tasks along the production process, such as technology management, passing on information, communicating statuses, and locating products, tools, and materials [23].

Therefore, the application of the socio-technical framework on the socially sustainable factory of the OP40 vision shows that this perspective remains anchored on the technical systems but with interest in the social system. The human agency is called OP40, and the literature reveals the potential socio-technical interplay between the two systems by the OP40 typology. The social and technical benefits are not so emphasised because the literature is devoted to developing an effective work system. However, we found that socially sustainable factory adoption delivers benefits on both systems.

Figure 4 illustrates the socio-technical perspective of the socially sustainable factory of the OP40.

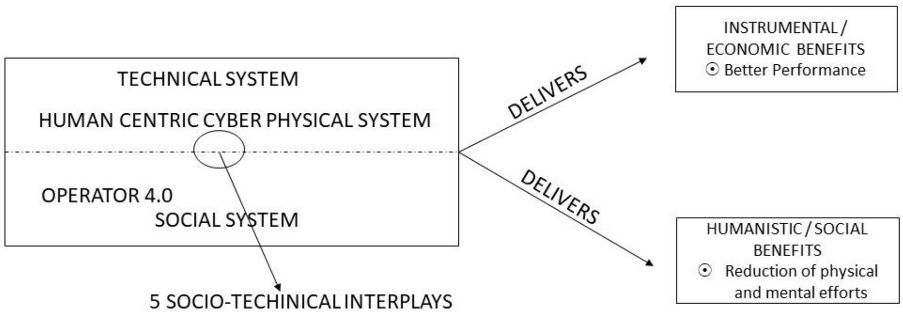

Figure 4 The Socio-technical perspective in the socially sustainable factory of Operator 4.0

5. Industry 5.0

The term "Industry 5.0" (I50) has been a buzzword circulating since the advent of I40. I50 is mainly used to debate the technocentric I40 vision that opens for several societal issues, particularly the job disruption and extensive surveillance of workers from the management. The literature reports various calls for actions of I50. The first authors using I50 were Ozdemir and Hekim [24] that debated how to reconcile human agency and technologies in an ever more connected world. To this end, the authors claim for a human-centric solution of such technologies, especially for cobots and artificial intelligence - that is not part of the I40 manifesto. Afterwards, in 2019, Nahavandi [25] proposes a further call for I50, stressing the necessity to find a solution that allows manufacturers to increase productivity while not removing human workers from the manufacturing industry. He also claims that the adoption of I50 will create new job positions, particularly the Chief Robotics Officer (CRO). This role is in charge of managing robots and their interactions with humans. Finally, in 2021, the European Commission launched a more articulated call for actions for I50 [15]. I50 is based on three pillars: human-centric, sustainable and resilient. The pillar of *human-centric* refers to the development of a production system that includes workers. They use the OP40 [12] typologies to illustrate the human agencies stressing the importance of digital competencies development and the maintenance of knowledge of production activites for workers. The pillar *sustainable* refers to a production system that mitigates the environmental impacts of the manufacturers, promoting energy-saving, cleaner production, and circular economy practices. The pillar *resilient* refers to the organisation attitude to overcome economic crisis – such as covid 19 – and maintain competitive advantages over competitors. Such conceptualisation with three pillars resembles the triple bottom line of sustainability, claiming that the organisation should seek profitability mitigating social and environmental issues [4].

The technologies involved in the revolution are the same as I40 plus artificial intelligence, cobots and exoskeleton that are used to automate activities in an ethical and fair way towards workers: they automate repetitive activities leaving creative and problem-solving activities to the workers [26–28].

Therefore, the application of the socio-technical framework on I50 vision shows that it is socio-technical in nature. The social system is emphasised as much as the technical system. We found that the OP40 role is also linked to the need for up-skill, especially for digital skills. The technical system involves a human centre production system where automation is used in an ethical way. It is also important that the I50 includes the so-called systematic sustainability where the socio-technical system aims to produce economic benefits for the organisation, social benefits for workers and address environmental issues for the world. Figure 5 illustrates the socio-technical perspective of I50.

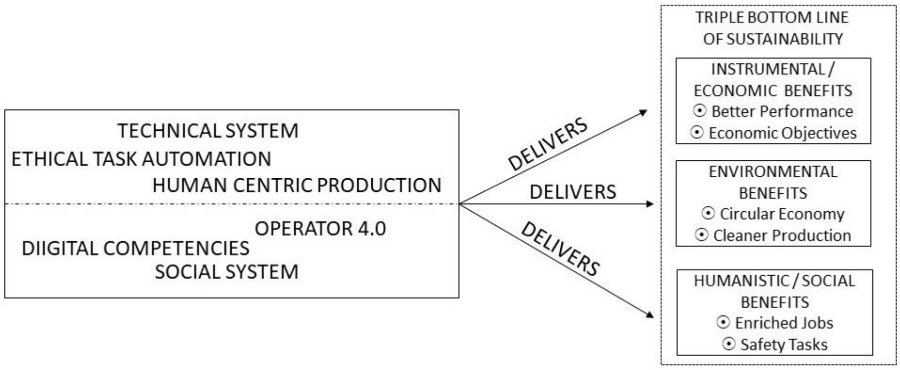

Figure 5 The Socio-technical perspective in industry 5.0

6. Discussion

The literature review reveals three main visions of the fourth industrial revolution: I40, the socially sustainable factory of OP40 and I50. Chronologically wise, we noted that there is a shift from a technocentric perspective, where social systems are not considered, towards a more complex socio-technical perspective. Starting from the I40 vision, there is a lack of interest in exploring the role of workers. The job disruption risk that I40 automation poses to society is the enabler for creating different perspectives of the fourth industrial revolution. The socially sustainable factory of OP40 adds a sort of typology for OP40 that can be used as an aid to design technologies allowing human interaction. This "human inclusion" premise to the production system is embraced by the I50 vision that is socio-technical in nature, and it is very promising for our society. Indeed, it can be used as a way to address job disruption that is problematic when technology automation plays a crucial role in the production processes. In addition, I50 allows linking the socio-technical theory with the triple bottom line of sustainability. This possibility is very important for socio-technical scholars because we can move from the "humanisation" of the workplace to the development of a "sustainable" world. More specifically, we can use the socio-technical theory to explain how the human and technological interplay serves to address internal issues of the organisations – in terms of job satisfaction and for an efficient and clean production – and external worldwide issues - like the increasing pollution and better quality of life.

6.1. Implication for researchers and practitioners

The study has certain implications for researchers. The study results are a starting point to explore the socio-technical perspective of the fourth industrial revolution. We propose some research avenues that socio-technical scholars can pursue:

- Digital skill is a complex concept that was unpacked by Van Laar et al. 2017 that propose a list of contextual and core digital skills [29, 30]. It is a pivotal component of the social system and deserves further attention. Starting from this study, we encourage qualitative and quantitative studies that create a list of the needed digital skills for the fourth industrial revolution and test it. Also, it is valuable to create a list of digital skills in conjunction with the OP40 typology.
- Knowledge is not an object which can be captured, stored and transferred. Automation can impact the workforce activities for knowledge sharing and transfer within organisations, which hamper the workforce share to acquire know-how for superior performance. Thus, it is valuable to study how these activities can change in the fourth industrial revolution. What are the knowledge sharing and transfer activities in the highly automated production system, such as organisations involving the fourth industrial revolution?
- Socio-technical theory can also be used to explore how the management and workers pass from the traditional work system to a novel I40/I50 production system. In this way,

researchers can shed light on the socio-technical barriers imputing organisations to adopt such technologies, the potential drawback of the social systems, and the practical socio-technical interplay in the fourth industrial revolution.

The study proposes various implications for practitioners and policymakers. Practitioners can exploit this article to explore the role of workers in complex automated production systems understating that workers keep creating value for the organisations. Policymakers can use this study to corroborate the need to develop industrial plans that provide funds for the skill development of manufacturing workers.

7. Conclusion

The aim of the study is to illustrate a socio-technical perspective of the fourth industrial revolution. Since scholars and practitioners forecast this revolution, we found in literature three main visions: I40, the socially sustainable factory of the OP40 and I50. Thus, we illustrate a socio-technical perspective for each vision. To this end, we conduct a literature review in order to detect the manifesto and systematic literature review for each vision. The result shows that I40 is technocentric and does not consider the social system. The socially sustainable factory of OP40 starts considering social systems stressing on the OP40 and the potential interplay between the two systems. In contrast, I50 is socio-technical in nature and includes the necessity to pursue sustainability outcomes (economic-environmental and social) rather than the traditional outcome of a work system. We finally propose some recommendations to continue the study of the socio-technical perspective in the fourth industrial revolution.

The study has limitations. We present the preliminary results of a literature review that we conducted on Scopus and Google Scholar, analysing only English articles. Future studies should overcome our study limitation by performing a literature review in different databases—such as WoS, EBSCO, Scopus, Science Direct and Google Scholar—examining papers in different languages.

8. References

1. Margherita, E.G., Esposito, G., Escobar, S.D., Crutzen, N.: Exploring the Smart City Adoption Process: Evidence from the Belgian urban context. In: Proceedings of the 6th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2020), June 8-9, 2020. CEUR Workshop Proceedings (CEUR-WS.org) (2020).
2. Margherita, E.G.: Achieving Sustainable Outcomes Through Citizen Science: Recommendations for an Effective Citizen Participation. In: A.M.A., M.A.-S. (ed.) The Big Data-Driven Digital Economy: Artificial and Computational Intelligence. Studies in Computational Intelligence, vol 974. Springer, Cham (2021).
3. Escobar, S.D., Margherita, E.G.: Emanuele Gabriel Margherita Emanuele Gabriel Margherita Outcomes of Smart Tourism Applications On-site for a Sustainable Tourism: Evidence from Empirical Studies. In: A.M.A, M.A.-S. (ed.) The Big Data-Driven Digital Economy: Artificial and Computational Intelligence. Studies in Computational Intelligence, vol 974. Springer, Cham (2021).
4. Braccini, A.M., Margherita, E.G.: Exploring Organizational Sustainability of Industry 4.0 under the Triple Bottom Line: The Case of a Manufacturing Company. Sustainability. 11, 36 (2019). https://doi.org/10.3390/su11010036.
5. Kagermann, H., Wolfgang, W., Helbig, J.: Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Work. Group. Acatech, Frankfurt am Main, Ger. (2013).
6. Margherita, E.G., Braccini, A.M.: Managing the Fourth Industrial Revolution: A Competence Framework for Smart Factory. In: Hamdan A., Hassanien A.E., Razzaque A., A.B. (ed.) The Fourth Industrial Revolution: Implementation of Artificial Intelligence for Growing Business Success. Studies in Computational Intelligence. Springer, Cham (2021). https://doi.org/https://doi.org/10.1007/978-3-030-62796-6_23.
7. Müller, J.M., Buliga, O., Voigt, K.I.: Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. Technol. Forecast. Soc. Change. 132, 2–17 (2018).
8. Beltrami, M., Orzes, G., Sarkis, J., Sartor, M.: Industry 4.0 and sustainability: Towards

conceptualization and theory. J. Clean. Prod. 312, 127733 (2021). https://doi.org/10.1016/j.jclepro.2021.127733.
9. Margherita, E.G., Braccini, A.M.: Industry 4.0 technologies in flexible manufacturing for sustainable organizational value: reflections from a multiple case study of italian manufacturers. Inf. Syst. Front. (2020).
10. Vereycken, Y., Ramioul, M., Desiere, S., Bal, M.: Human resource practices accompanying industry 4.0 in European manufacturing industry. J. Manuf. Technol. Manag. ahead-of-p, 1016–1036 (2021). https://doi.org/10.1108/jmtm-08-2020-0331.
11. Veile, J.W., Kiel, D., Müller, J.M., Voigt, K.I.: Lessons learned from Industry 4.0 implementation in the German manufacturing industry. J. Manuf. Technol. Manag. 31, 977–997 (2020). https://doi.org/10.1108/JMTM-08-2018-0270.
12. Bonekamp, L., Sure, M.: Consequences of Industry 4.0 on human labour and work organisation. J. Bus. Media Psychol. 6, 33–40 (2015).
13. Meindl, B., Ayala, N.F., Mendonça, J., Frank, A.G.: The four smarts of Industry 4.0: Evolution of ten years of research and future perspectives. Technol. Forecast. Soc. Change. 168, (2021). https://doi.org/10.1016/j.techfore.2021.120784.
14. Romero, D., Stahre, J., Wuest, T., Noran, O., Bernus, P., Fast-Berglund, Å., Gorecky, D.: Towards an Operator 4.0 Typology: A Human-Centric Perspective on the Fourth Industrial Revolution Technologie. CIE46 Proc. (2016).
15. Breque, M., Lars, D.N., Athanasios, P.: Industry 5.0. European Commission (2021). https://doi.org/10.2777/308407.
16. Sarker, S., Chatterjee, S., Xiao, X., Elbanna, A.: The Sociotechnical Axis of Cohesion for IS discipline: its historical legacy and its continued relevance. MIS Q. 43, 695–719 (2019).
17. Sarker, S., Chetterjee, S., Xiao, X.: How "Sociotechnical" Is Our Is Research? An Assessment and Possible Ways Forward. R. Baskerville, M. Chau (Eds.), Proc. 34th Int. Conf. Inf. Syst. ICIS 2013. 1–24 (2013).
18. Margherita, E.G., Braccini, A.M.: Examining the development of a digital ecosystem in an Industry 4.0 context: a sociotechnical perspective. SN Bus. Econ. (2021). https://doi.org/10.1007/s43546-021-00096-z.
19. Webster, J., Watson, R.T.: Analyzing the Past To Prepare for the Future : Writing a literature review. MIS Q. 26, (2002).
20. Kang, H.S., Lee, J.Y., Choi, S., Kim, H., Park, J.H., Son, J.Y., Kim, B.H., Noh, S. Do: Smart manufacturing: Past research, present findings, and future directions. Int. J. Precis. Eng. Manuf. - Green Technol. 3, 111–128 (2016).
21. Margherita, E.G., Bua, I.: The role of Human Resource Practices for the development of Operator 4.0 in Industry 4.0 organisations: A literature review and a Research Agenda. Businesses. 1, 18–33 (2021). https://doi.org/https://doi.org/10.3390/businesses1010002.
22. Romero, D., Stahre, J., Taisch, M.: The Operator 4.0: Towards socially sustainable factories of the future. Comput. Ind. Eng. 139, (2020). https://doi.org/10.1016/j.cie.2019.106128.
23. Tarrar, M., Thorvald, P., Fasth-berglund, Å., Romero, D.: Challenges for the Operator 3.0 Addressed Through the Enabling Technologies of the Operator 4.0. In: In: Lalic B., Majstorovic V., Marjanovic U., von Cieminski G., R.D. (ed.) Advances in Production Management Systems. Towards Smart and Digital Manufacturing. APMS 2020. IFIP Advances in Information and Communication Technology, vol 592. pp. 1–8. Springer, Cham (2020).
24. Özdemir, V., Hekim, N.: Birth of Industry 5.0: Making Sense of Big Data with Artificial Intelligence, "the Internet of Things" and Next-Generation Technology Policy. Omi. A J. Integr. Biol. 22, 65–76 (2018). https://doi.org/10.1089/omi.2017.0194.
25. Nahavandi, S.: Industry 5.0—A Human-Centric Solution. Sustainability. 2–9 (2019).
26. Longo, F., Padovano, A., Umbrello, S.: Value-oriented and ethical technology engineering in industry 5.0: A human-centric perspective for the design of the factory of the future. Appl. Sci. 10, 1–25 (2020). https://doi.org/10.3390/APP10124182.
27. Javaid, M., Haleem, A., Singh, R.P., Ul Haq, M.I., Raina, A., Suman, R.: Industry 5.0: Potential applications in covid-19. J. Ind. Integr. Manag. 5, 507–530 (2020). https://doi.org/10.1142/S2424862220500220.
28. Demir, K.A., Döven, G., Sezen, B.: Industry 5.0 and Human-Robot Co-working. Procedia

Comput. Sci. 158, 688–695 (2019). https://doi.org/10.1016/j.procs.2019.09.104.
29. van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., de Haan, J.: The relation between 21st-century skills and digital skills: A systematic literature review. Comput. Human Behav. 72, 577–588 (2017). https://doi.org/10.1016/j.chb.2017.03.010.
30. Prezioso, G., Margherita, E.G.: Exploring Organizational Strategies for Development of Digital Skills: A Case Study. In: A.M.A., M.A.-S. (ed.) The Big Data-Driven Digital Economy: Artificial and Computational Intelligence. Studies in Computational Intelligence, vol 974. Springer, Cham (2021).