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# A Review of Implementation of Industry 4.0 in Manufacturing Sector

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***Abstract:*** ***The purpose of this article is to review the latest work on Industry 4.0 through articles published between January 2017 and April 2021, and to understand the current state of the industry 4.0 research level. The detailed literature review method uses a step-by-step article selection method, including: database selection, keyword selection, article collection, inclusion/exclusion criteria and selected article reviews. Most work is based on concepts or case studies. However, empirical research is needed in this area. The future research directions provided in this document may be helpful to researchers who are willing to conduct research in the field of Industry 4.0. Researchers related to Industry 4.0 have aroused great interest, leading to many publications on different Industry 4.0 topics. This document will help to obtain future research directions.***
***Keywords: Digital Transformation, Industry 4.0, Barriers, Cyber Physical System, Smart Factory, Internet of Things***

## I. INTRODUCTION

The fourth industrial revolution, Industry 4.0, brings a new perspective to the manufacturing industry, which can be combined with emerging technologies to achieve efficient production and optimize the use of resources in the manufacturing industry. The German government's Industry 4.0 plan merges manufacturing and IT (Kamble et al., 2018). The first industrial revolution began with the introduction of the steam engine, the second batch of industrial revolutions focused on mass production, and the second industrial revolution began with the development of computer technology. The digital revolution began with the development of computerization and the creation of networks in all areas of production, which led to the fourth industrial revolution. Industry 4.0 can be defined as the integration of information technology and cyber-physical systems (CPS). Emerging technologies such as smart machines, cloud computing, and data-sharing production facilities trigger actions and controls independently of each other, creating a cyber-physical system (CPS). Any organization with Industry 4.0 has great potential to realize social and economic benefits and integrate the use of artificial intelligence, the Internet of Things (IoT) and big data. As the Internet of Things (IoT) improves the way CPS interact, monitor, control, and manage, CPS facilitates the integration of processes and systems into organizational and manufacturing technologies. It can improve cooperation and communication between production departments, innovate production, improve services, improve logistics, and carry out effective and cost-effective resource planning. The latest development of ICT tools has promoted the development of Industry 4.0. The development and progress of emerging technologies in Industry 4.0 will provide a series of feasible solutions to meet the growing needs of the manufacturing industry. First of all, the idea of the “fourth industrial revolution” may sound better. It should be noted that its implementation involves many challenges, risks and obstacles. Defining the correct infrastructure and standards, ensuring data security and training employees are some of the problems that need to be solved on the road to Industry 4.0 (Hofmann & Rüsch, 2017). Therefore, it is necessary to determine the current research status and future scope of Industry 4.0.

This research attempts to focus on the latest works published from January 2017 to April 2021. This article reviews a total of 36 articles and research papers, which were published in different journals. In addition, the structure of the document is as follows. A detailed review of the literature in tabular form. The next section provides research methods for selecting articles, followed by the discussion in section 3. The conclusion is provided in the last part of this article.

## II. REVIEW METHODOLOGY

Reviewing the literature is an important part of any research work. Through literature review, the relevant literature is evaluated and analyzed to find out the research gaps that help strengthen the research field. Use various available databases related to knowledge exchange, knowledge transfer and knowledge flow for literature review. To this end, the author has submitted various articles to the database, i.e., Web of Science (WoS) and ProQuest, which contain a large number of well-known publications, such as Emerald, Taylor and Francis, Springer, IEEE and Elsevier. The structured review method uses a five-step process, as shown in Figure 1.

Develop a search strategy by first looking at the relevant data source (ie the database). In order to access various academic and conference publications, Web of Science and ProQuest databases were selected.

The most relevant and appropriate articles are cited in this document. Therefore, the keywords used in the search process are very specific. Industry 4.0, smart manufacturing, smart factory, etc. As of 2015, a total of 210 articles have been generated, which are the main search results. It does not include articles published in different book chapters, reports, doctoral dissertations and editorial notes. Then the item is reduced to 84.

Since the focus of this article is to review the latest articles, articles published between January 2017 and April 2021 are selected. These articles come from "Smart Manufacturing Magazine", "Manufacturing Technology Management Magazine", "Human Resource Management International Abstract", Sustainability, Energy, International Production Research Journal, Computer and Industrial Engineering, Advanced Manufacturing, Industrial Computer, Industrial and Production Engineering Journal, IEEE Industrial Informatics and Process Safety and Environmental Protection Transactions have high reliability in this article. Then, the number was reduced to 36 articles selected for the study.

Table 1: Literature Review

| Sr. No. | Investigators | Type of Research | Focus of the study | Contribution |
|---|---|---|---|---|
| 1 | Tortorella & Fettermann, 2017 [3] | Empirical/Case Study | Examine the lean relationship between Lean Manufacturing (LP) practices and the implementation of Industry 4.0 | LP practices have a positive connection with Industry 4.0 technology, and their simultaneous implementation can further improve performance. |
| 2 | Hofmann & Rüsch, 2017 [2] | Conceptual | Look for opportunities for I4.0 in the context of logistics-management. | After interviewing experts, the authors determined and discussed the significance of Industry 4.0 in the field of logistics management. |
| 3 | Wang et al., 2017 [4] | Conceptual | It proposes a framework for mass customization production based on the concept of Industry 4.0. | In order to bridge the gap between mass personalization and mass personalization, this document proposes an MCP framework based on the concept of "Industry 4.0". |
| 4 | Strandhagen et al., 2017 [5] | Case Study | Identify and analyse the I4.0-technologies applicable to manufacturing logistics and how the production environment affects the applicability of these technologies. | Research shows that the applicability of I4.0 in manufacturing-logistics depends on the production environment. Companies with lower production repeatability have less potential to apply Industry 4.0-technology to manufacturing-logistics, while companies with higher repeatability have greater potential. |
| 5 | Li et al., 2017 [6] | Case Study | Develop a systematic approach and gain an in-depth understanding of predictive maintenance in the age of Industry 4.0. | A system-framework based on the I4.0 concept, which includes failure analysis and processing procedures for predictive maintenance of the machine center. |
| 6 | Bodrow, 2017 [7] | Conceptual | Analyze the general concepts and methods of Industry 4.0. | A brief review of the interdependence between Industry 4.0 |
| 7 | Longo et al., 2017 [8] | Empirical | Design and develop practical solutions that can support complex human-computer interaction. | A practical solution called SOPHOS-MS was developed to assist human-computer interaction. |
| 8 | Theorin et al., 2017 [9] | Conceptual | Quickly integrate smart services into existing factory infrastructure | With the help of the line information system (LISA) architecture, innovative and simple architecture and design patterns. |
| 9 | Liao et al., 2017 [10] | Literature Review | Systematically review the latest state of Industry 4.0 | Reported on the status quo of the fourth industrial revolution by analyzing the academic progress of Industry 4.0 |
| 10 | Shamim.et al., 2017 [11] | Conceptual | Explore Industry 4.0 issues in the service industry. | It provides a framework for management practices that can promote innovation and learning-environments in the organization. |
| 11 | Lin et al., 2017 [12] | Case Study | Reveal the trends of competition and alliances, and analyze the content of cross-strait I4.0 policies | When adopting innovative policies to develop Taiwan Strait Industry 4.0, different strategies were revealed. |
| 12 | Gonzalez et al. 2018 [13] | Empirical | A supervisory control method for the navigation of mobile robots in industry is proposed. | Using discrete event simulation, the navigation architecture proposed in this document is illustrated in a hypothetical smart factory environment. |

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| 13 | Schluse et al., 2018 [14] | Conceptual | It proposes a new structural element for the simulation-based engineering process, called the "experience digital twin" | It introduces the concept of EDT, which is a new structural element of simulation-based system engineering process and its interdisciplinary and multi-domain simulation. |
| 14 | Moeuf.et al., 2018 [15] | Literature Review | Provides a review of existing applied research literature, covering different Industry 4.0 topics related to SMEs. | The Industry 4.0 SME project is still a cost-driven program, and there is no evidence that the business model has really changed. |
| 15 | Yin et al., 2018 [16] | Conceptual | The relationship between product supply and customer demand in industry 2.0–4.0 | He explained the scale of industry 4.0 demand, changes in the product structure of the automotive industry and the impact of 3D printing. |
| 16 | Fettermann et al., 2018 [17] | Case Study | Determine the contribution of adopting Industry 4.0 technology to the company's operations management (MO). | The results of 38-case studies show that the contribution of I4.0 is more concentrated in areas such as technology-management and just-in-time manufacturing. |
| 17 | Xu et al., 2018 [18] | Literature review | To inform industry about current developments and future opportunities in the exciting field of Industry 4.0. | It provides various research opportunities related to CPS, blockchain and logistics in the field of Industry 4.0. |
| 18 | Buer et al., 2018 [19] | Literature Review | Explore the latest literature on lean manufacturing and Industry 4.0. | Build a connection between lean manufacturing and Industry 4.0 |
| 19 | Müller et al., 2018 [20] | Empirical | Examine the relevance of Industry 4.0 opportunities and challenges related to sustainability. | Strategic, operational, environmental and social opportunities are the positive driving force for the implementation of Industry 4.0 |
| 20 | Kamble et al., 2018 [1] | Literature Review | Find different research methods and understand the current state of research. | Based on the results of the review, a sustainable industry 4.0 framework with three key elements is proposed, namely, industry 4.0 technology, process integration and sustainable results. |
| 21 | Sivathanu et al.,2018 [21] | Conceptual | To determine the challenges to HR due to Industry 4.0 | To effectively implement SHR4.0, organizational structure and leadership style must be changed |
| 22 | Ghobakhlooet al., 2018 [22] | Literature Review | Carry out the work list on Industry 4.0 | This study provides a comprehensive understanding of the common steps that manufacturers need to take to transition to Industry 4.0. |
| 23 | Viryasitavat et al., 2018 [23] | Conceptual | Research on BPM-solutions aims to select and combine services in an open business environment | The BPM framework was developed to illustrate how to integrate BCT to support fast, reliable and cost-effective evaluation |
| 24 | Kong et al., 2018 [24] | Conceptual | A critical issue of integration between human and machines or robots | Establish a symbiotic relationship between man and nature to support real-time, credible and dynamic interactions between operators, machines and production systems |
| 25 | Pereria A. et. al. 2019 [25] | Literature Review | This article focuses on the concept of Industry 4.0 and helps to clarify and understand the importance and meaning of this complex technological system. | It has been suggested that in order to improve process efficiency and competitiveness, companies moving towards Industry 4.0 need to be aware of all aspects that may be affected and their main implications, as well as innovation opportunities. |
| 26 | Alcácer V. et. al. 2019 [26] | Literature Review | Supporting technology, focusing on the latest technology and future trends. The I4.0 manufacturing system method in this article is based on the Smart Factory (SF) concept. | For example, SaaS can be used to promote the implementation of I4.0 in small and medium-sized enterprises, so as to obtain digital service technology with attractive investment. An obvious example is the integration of small and medium-sized enterprises into the supply chain of products, so that project development collaboration can be carried out, collaboration in product release and shortening time to market, sharing innovation and thus minimizing related risks. |

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| 27 | Türkes MC et. al. 2019 [27] | Empirical | Determine the views and opinions of managers of Romanian small and medium-sized enterprises on the driving factors and obstacles of implementing Industry 4.0 technology to promote business development<br>Use of SPSS to analyze the collected data using frequency tables, contingency tables and principal component analysis. | The first limitation of this study is related to the size of the sample and the reduction in size. This is due to the low response rate, which leads to the respondent's self-selection process (PME). Second, it should be remembered that the data on the surveyed population is obtained from the metadata database of the National Bureau of Statistics (INSSE). |
| 28 | Sony M. et. al.2018 [28] | Literature Review | Determine the key factors that assess the organization's readiness for Industry 4.0, the interrelationship between these preparatory factors, and how future research should be conducted given the results of the research. | The SLR results produced a broad theme of six readiness factors. The mechanism of the interrelationship between these factors has been determined. |
| 29 | Stentoft Jan et. al.2019 [29] | Empirical | The readiness of small and medium-sized manufacturers for digital manufacturing and their actual practices in this field. | The empirical evidence provided shows that the perceived factors of Industry 4.0 lead to a better state of Industry 4.0 readiness, which in turn leads to a higher degree of Industry 4.0 practice. It was also found that obstacles made the company insufficiently prepared for Industry 4.0, but this obviously has no significant impact on the practice of Industry 4.0. |
| 30 | Rawat P et al. 2019 [30] | Literature Review | The Industry 4.0 literature was reviewed to understand its technical dimensions. The purpose of this study is to review the challenges that will affect the implementation of Industry 4.0 in the Indian manufacturing industry. | For the successful implementation of Industry 4.0, these six key elements are very important because they are interrelated. Therefore, when implementing "Industry 4.0", organizations should consider these factors as a whole. |
| 31 | Rawat P et al. 2019 [31] | Literature Review | He introduced the obstacles to the adoption of I4.0 by India's micro, small and medium enterprises (MSME). | Through extensive literature review, the main obstacles to the implementation of "Industry 4.0" projects in MSMEs in India have been identified. This literature review classifies the barriers that hinder MSME's successful implementation of Industry 4.0 technologies and prioritizes them according to their impact on the technological development of Indian manufacturing and the companies' effective concepts of Industry 4.0 in emerging economies. |
| 32 | Yadav et al.2020 [32] | Empirical | The importance of digital supporters to sustainable companies | Construction related to economy and management is the facilitator |
| 33 | Yadav et al. (2020b) [33] | Empirical | Measures to solve digital challenges | Administrative and organizational challenges and economic challenges |
| 34 | Kumar et al. (2020) [34] | Empirical | Identify the challenges of adopting Industry 4.0 technologies | The lack of motivation for partners and customers to use I4.0 technology is the main challenge |
| 35 | Sivananda et al. (2020) [35] | Empirical | Analyze the factors conducive to the implementation of Industry 4.0 in the manufacturing industry. | The seven driving forces of big data, visual computing, horizontal and vertical integration, cyber-physical systems, supply chain and leadership undoubtedly play an important role in the implementation of Industry 4.0. |
| 36 | Rawat P et al. 2020 [36] | Literature Review | Review the work done on Industry 4.0 and its implementation in manufacturing | Most work is based on concepts or case studies. |

## III. DISCUSSION ON LITERATURE REVIEW

The development of Industry 4.0 may gradually increase with the focus on the growth of existing technologies. The growth of research and publications shows the rapid development of industry 4.0 topics by scholars and industry experts. However, some topics related to Industry 4.0 are still lagging behind, and there may be opportunities for further research. Several research opportunities have been identified and described below.

*A.* To date, there is no universally accepted definition of Industry 4.0. Therefore, future research and publication may aim to develop a concept that can be well accepted by all or most scholars and industry experts.

*B.* Many studies focus on technology management and general discussion of Industry 4.0 concepts and theories. However, empirical research is needed to verify the theories and concepts of Industry 4.0.

*C.* More empirical research methods such as simulation, prototypes, experiments and case studies are needed to accelerate the use of Industry 4.0 in all fields.

*D.* The lack of research on human-machine interface, human resource management in Industry 4.0, sustainability and the interaction between machines and teams means that open research fields should be explored in future research.

## IV. CONCLUSION

The purpose of this work is to conduct a detailed review of the 36 latest articles on the concept of Industry 4.0 published between January 2017 and April 2021, and emphasize the types of research, research methods, and contributions of various studies. These articles also provide opportunities for future research. The research is expected to help accelerate the momentum of Industry 4.0 investigations.

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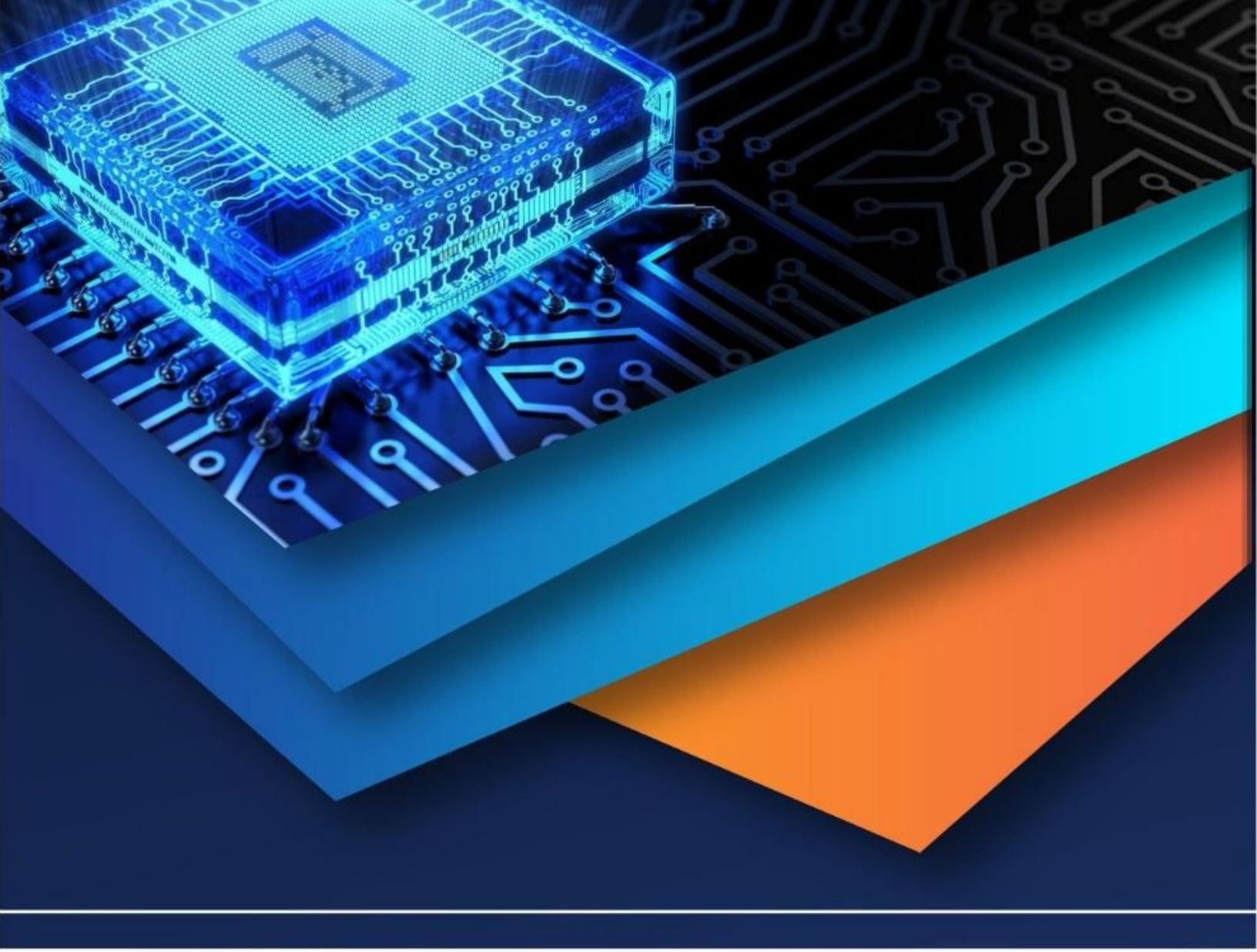

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