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# Knowledge Management and the Fourth Industrial Revolution (4IR): A Recent Systematic Review

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**ABSTRACT**

Concerning the Fourth Industrial Revolution (4IR) era, associated with the rapid integration related to advanced technologies like Artificial Intelligence (AI), blockchain, and the IoT (Internet of Things) into society, effective Knowledge Management (KM) is crucial for organizations in this dynamic landscape. This systematic review explores the evolving relationship between KM and 4IR, addressing how organizations adapt their KM practices to leverage 4IR technologies and address associated challenges. Our review examines recent research in KM and 4IR, highlighting key themes, trends, and findings. Using a rigorous systematic review methodology, final primary data (n=28) published between 2021 and 2023 through advanced searches in Scopus and Econbiz databases were analyzed. The results reveal a dynamic landscape where organizations embrace 4IR technologies to enhance knowledge creation, storage, sharing, and application. The synthesis of existing research underscores the need for a strategic and adaptable KM approach in the 4IR era, emphasizing the critical roles of organizational culture, leadership, and technological infrastructure in shaping successful KM practices in this transformative context. This systematic review serves as a guide for scholars, professionals, and decision-makers, aiding them in navigating the complexities of 4IR and emphasizing the value of knowledge as a key resource in this evolving field.

## 1. Introduction

In the fast-evolving landscape of technology and industry era, the relationship that exists between Knowledge Management (KM) and the Fourth Industrial Revolution (4IR) refers to an important and relevant area of study. The Fourth Industrial Revolution (4IR) which is also known as "Industry 4.0", involves the integration of the Internet of Things (IoT), cyber-physical systems, Artificial Intelligence (AI) as well as data analytics into manufacturing processes, represents a significant shift in how industries operate [1-3]. However, this shift is not just about adopting new

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technologies; it also involves effectively managing and utilizing knowledge assets within this digitalized industrial ecosystem [4]. Combining KM principles with 4IR offers a comprehensive approach to improving organizational performance, innovation, and competitiveness [5,6] (see Figure 1). Figure 1 shows the importance of KM enablers (T-shaped skills, collaboration, Information Technology (IT) support, and learning in the knowledge creation process and organizational performance. In the context of 4IR, knowledge goes beyond explicit information. It includes tacit, experiential, and contextual insights that are crucial for making informed decisions and ensuring sustainable development [6].

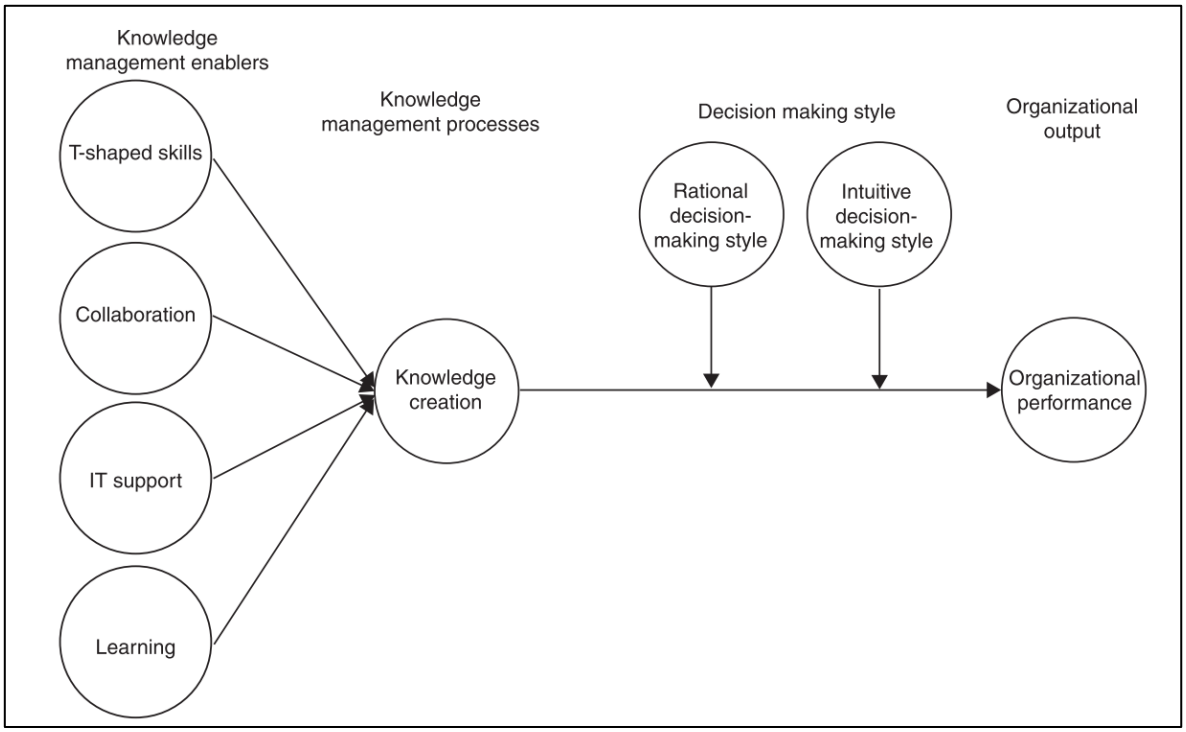


**Fig. 1.** KM as well as decision-making strategies as factors with regard to organizational performance in 4IR [6]

This review recognizes the importance of understanding how KM principles are utilized with 4IR technologies. It acknowledges that this knowledge is crucial for academic discussions and has significant implications for industries, policymakers, and practitioners. It contributes to a precise understanding of how KM practices have been affected and shaped by the advent of the 4IR [7,8]. The findings can inform future research, forecasting, and technology foresight in the domains of knowledge management, 4IR, and related areas. This review's objective is to evaluate the current state of understanding regarding this subject, determine gaps in the existing literature, and combine crucial discoveries to present a comprehensive insight into how organizations modify their KM strategies during the age of the 4IR. Through a thorough examination of the existing literature, this review offers a more profound grasp of the obstacles and prospects that emerge from the intersection of KM and 4IR. It can contribute to the development of strategies that can empower organizations to thrive in the digital age. This systematic review is a compass that can guide scholars, professionals, and decision-makers through the complex landscape of 4IR and able to help them better comprehend this evolving field, where knowledge is not just a resource but the currency of progress.

## 2. Literature Review

The Fourth Industrial Revolution (4IR), also known as “Industry 4.0 (I4.0)”, comprises various terms, for example, "smart manufacturing," "industrial internet," as well as the "Factory of the Future" [9]. This concept, coined by Klaus Schwab, describes a world where individuals seamlessly navigate between digital and offline realms, utilizing connected technology to enhance and manage their lives. It results from advanced technology, global economic integration, expanded education, legal frameworks, cultural traditions, and human relationships [10]. The 4IR is distinguished by the incorporation of cutting-edge technologies like automation, expert systems, Artificial Intelligence (AI), Cyber-Physical Systems (CPS), Internet of Things (IoT), smart sensors, big data analysis, Internet of Services (IoS), additive manufacturing (3D Printing), autonomous robots, Augmented Reality (AR), as well as cloud computing (see Figure 2), aiming at optimizing productivity and efficiency [11,12]. The 4IR also has transformed countries like Malaysia into rapidly developing country [13]. Despite the increasing attention from manufacturers, business leaders, as well as academicians, the successful implementation with regard to 4IR relies on three crucial readiness criteria: management support, knowledge levels, and financial backing [14].

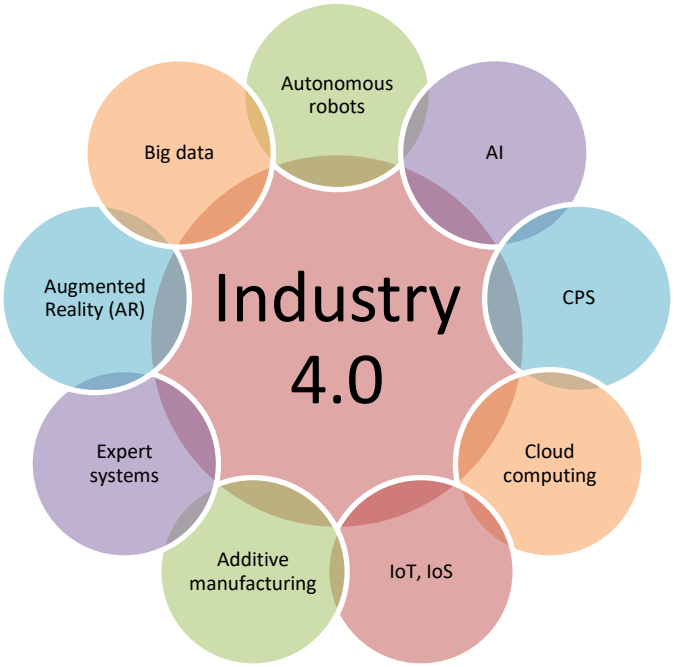


**Fig. 2.** 4IR related technologies [11]

As the 4IR expands across various industries, advanced technologies generate vast and diverse data and knowledge, highlighting the increasing need for effective KM to enable efficient reuse [15]. Knowledge is a critical resource for carrying out tasks, with results of the tasks are automatically stored in knowledge repositories, enabling quick decision-making and reducing work cycle times through knowledge reuse [16]. KM processes, which include activities such as knowledge generation, dissemination, acquisition, preservation, retrieval, and application within organizational frameworks, have also been notably impacted by the 4IR [17]. KM is undergoing a redefinition, particularly as a tool for fostering organizational growth and facilitating interactions between machines and human actors within an organization [8]. For KM to play its role in connecting people and machines, traditional leadership is incompatible. Creating intelligent leadership requires a highly innovative and

learning culture. The leadership style must be more open and focused on learning and expanding knowledge [18]. Figure 3 illustrates key skills that IR4.0 leaders should possess.

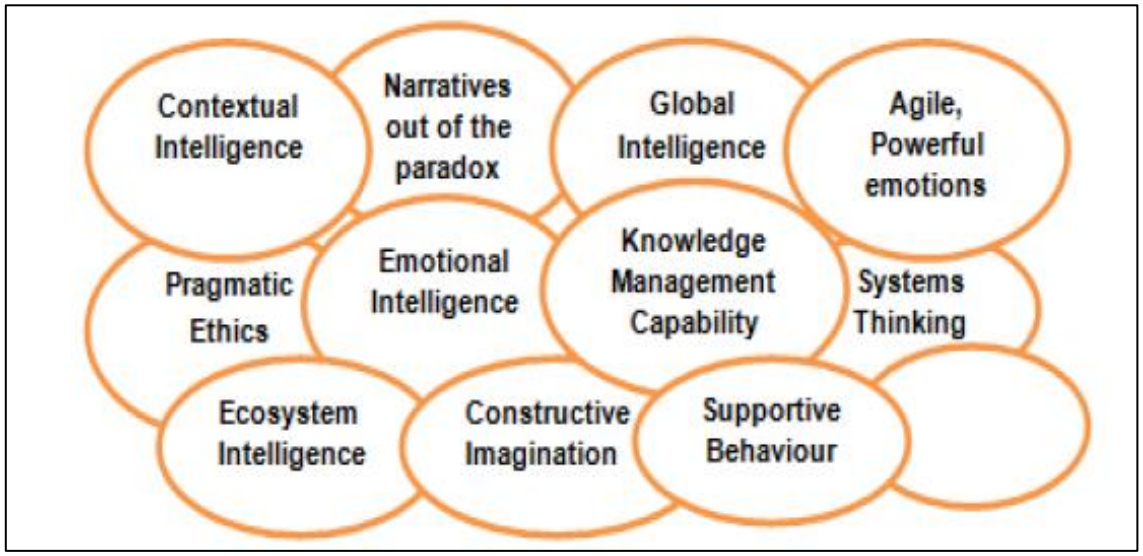


**Fig. 3.** 4IR Leaders' Key Skills [19]

Managing complex projects with regard to the 4IR presents KM challenges, including the need to enhance differential competitiveness and simplify value chains [20]. Over the past few decades, businesses have addressed these KM difficulties through social interaction and codification, often facilitated by Information and Communication Technology (ICT) [21]. However, in the 4IR era, AI emerged as a transformative technology capable of learning from past project outcomes to inform future ones. AI, alongside big data technologies, significantly enhances the efficiency of KM procedures by streamlining document retrieval and improving overall KM processes within enterprises [21]. Furthermore, in the 4IR organizational landscape, knowledge takes the form of "big data" received by sensors and transmitted to actuators, with analysis occurring within cloud-based cyber-physical systems. This necessitates a re-conceptualization with regard to the KM's role in endorsing organizational functions as well as its manifestation in an age where seamless human connectivity through ubiquitous technologies is prevalent [22]. Additionally, the KM adoption in harnessing new capabilities as well as skills among people is proof that KM offers competitive advantages and serves as a critical means concerning organizational survival. This allows the development with regard to core capabilities as well as the generation concerning new ones to navigate the challenges of the 4IR era [11].

## 3. Materials and Methods

### *3.1 Identification*

During the systematic review process, several phases were undertaken to select pertinent papers for this study. The initial phase involved identifying keywords and searching for associated terms using resources such as dictionaries, thesaurus, encyclopaedias, and past research. Once all the applicable keywords were selected, search strings were generated for the Econbiz as well as the Scopus database (see Table 1).

**Table 1**
The search strings

| | |
|---|---|
| Scopus | "Knowledge Management" AND ("Fourth Industrial Revolution" OR 4IR OR "Industry 4.0") |
| Econbiz | "Knowledge Management" AND ("Fourth Industrial Revolution" OR 4IR OR "Industry 4.0") |

The use of EconBiz and Scopus databases, as opposed to other databases like Web of Science (WoS), ScienceDirect, and others, is due to several reasons. EconBiz is the preferred database for the author, who specializes in business, due to its specific focus on economics and business studies [23], offering a more tailored collection of resources in these fields compared to broader databases like WoS or ScienceDirect. Additionally, Scopus is highly favored for its extensive citation analysis tools [24], which are essential for conducting this systematic literature review. Scopus also provides wider access to certain journals and publications, some of which might not be indexed in WoS, owing to its broader scope and more inclusive evaluation process [25]. This feature of Scopus ensures the inclusion of more journals and publications. Furthermore, Scopus is chosen over WoS or ScienceDirect for its user-friendly interface and efficient citation tracking features [26]. The availability and accessibility of these databases also play a crucial role, as the authors have free access to both EconBiz and Scopus, unlike other databases which are limited by institutional subscriptions and access rights. Hence, regarding the systematic review process, which primarily utilized the EconBiz and Scopus databases, 613 papers were successfully obtained in the first phase.

### *3.2 Screening*

In the screening stage, the researchers assessed potentially applicable research materials to ascertain if their content corresponded with the research items related to KM in the context of 4IR. Consequently, duplicate papers were eliminated from the compilation. In total, 124 papers were assessed in the second stage, while 489 publications were rejected in the first stage, as shown in Table 2. The first criterion used was to include only research articles, considered the main sources of valuable information. Conference proceedings, book chapters, books, meta-analyses, meta-synthesis, as well as reviews were removed from this study. Additionally, the review was limited to publications in English and focused on articles published between 2021 and 2023.

### *3.3 Eligibility*

During the eligibility phase, 120 items were prepared for assessment. In this stage, a thorough evaluation was conducted on the article titles and crucial content to ensure they satisfied the inclusion criteria and aligned with the study's objectives. Consequently, 90 papers were excluded because they were unrelated to the field, the title did not significantly correspond to the study's goal, and the abstract did not correspond. There was no access to full text based on empirical data. As a result, there are 30 articles available for review (refer to Table 2).

**Table 2**
The selection criterion in searching

| Criterion | Inclusion | Exclusion |
|---|---|---|
| Language | English | Non-English |
| Timeline | 2021 – 2023 | < 2021 |
| Literature type | Journal/Article | Conference paper, Book chapter, Conference review, Review, Book |
| Publication Stage | Final | In Press |

### *3.4 Data Abstraction and Analysis*

In this research, the integrative analysis served as among the evaluation approaches to investigate and synthesize various research designs, including mixed methods, qualitative, as well as quantitative. The primary objective of the expert study was to determine applicable subtopics as well as topics. The initial stage of theme development involved collecting data. As illustrated in Figure 4, a compilation of 613 publications to identify statements or content pertinent to the study's topics were analyzed. Subsequently, in the second phase, the progression of KM in 4IR by recognizing and establishing key groupings were assessed. The methodology yielded two primary subjects: 4IR technologies and KM practices. Following this, the authors continued to delve into each established subject, exploring associated themes, concepts, and ideas. Collaboration with co-authors was integral to crafting themes based on the evidence uncovered during the research. A detailed log was maintained throughout the data analysis process to report any analyses, perspectives, perplexities, or other considerations applicable to the data interpretation. Lastly, the outcomes were compared by the authors to identify any lack of consistency in the theme development process. Moreover, it is noteworthy that, in the event of disparities in concepts, the authors engaged in discussions to resolve them internally. Ultimately, the themes created were refined to ensure their coherence. KM specialists conducted the analysis to assess the validity of the issues. Through domain validity, the expert review phase contributed to verifying the clarity, significance, and appropriateness of every sub-theme. Correspondingly, adjusted judgments based on feedback and professional assessments were made.

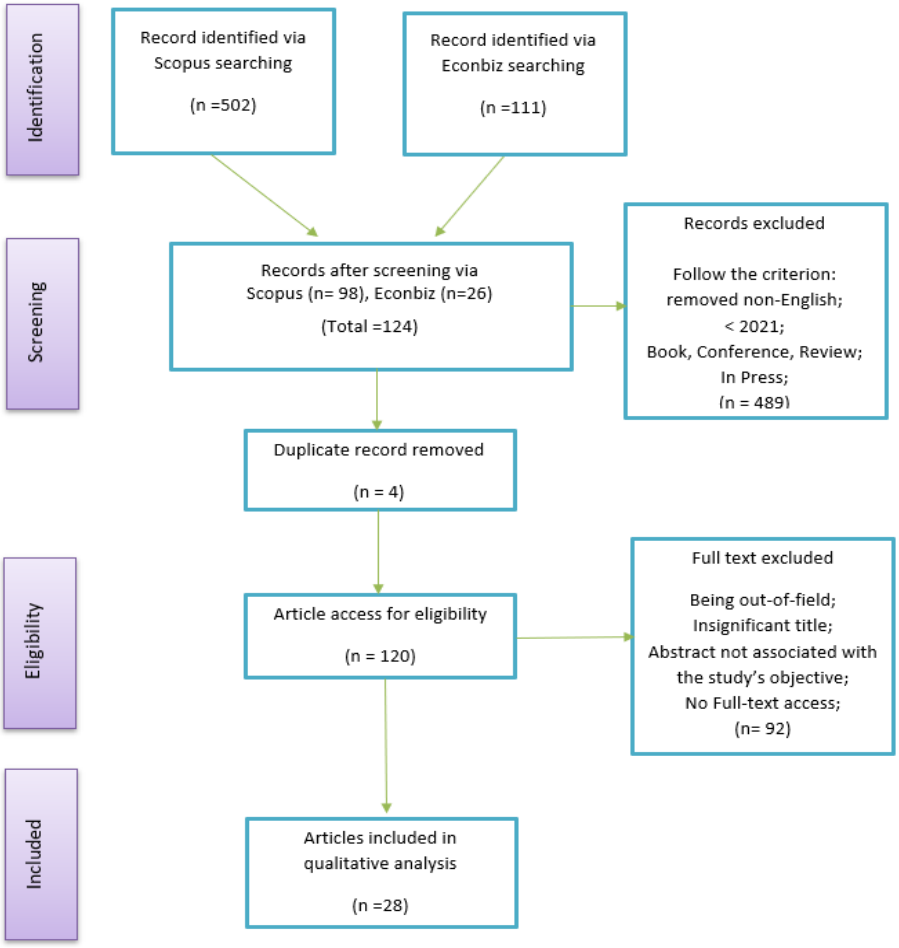


**Fig. 4.** Flow diagram with regard to the suggested searching study

## 4. Results and Findings

In this study context, Knowledge Management (KM) practices encompass the methodologies and strategies by which knowledge is created, stored, shared, and applied within organizations [27,28], particularly under the influence of the Fourth Industrial Revolution (4IR). These practices involve the generation and capture of new knowledge from a variety of sources in the digital era, characterized by an abundance of data [29]. They also include the methods for storing this knowledge in databases or digital repositories, emphasizing the importance of easy retrieval and access [30]. Additionally, the study considers the processes and platforms for distributing knowledge both internally and externally, utilizing digital tools and social networks [31]. Furthermore, it examines the effectiveness of applying this knowledge in decision-making, innovation, and problem-solving [6] within the evolving landscape of the 4IR.

Subsequently, the articles found were classified into three primary themes: 1) The Impact of 4IR technologies on KM practices (6 articles), 2) Challenges and Opportunities in 4IR KM (15 articles), and 3) Future Directions for KM in the 4IR Era (7 articles) – Table 3.

**Table 3**
The research article's findings relying on the suggested search criterion

| No. | Authors | Title | Year | Method | Remarks |
|---|---|---|---|---|---|
| 1. | Montoya-Quintero D.M.; Bermudez-Ríos L.F.; Cogollo-Flórez J.M. [32] | Model for Integrating KM System and Quality Management System in Industry 4.0 | 2022 | Descriptive, documentary, and quantitative data analysis via a survey. | Future Directions and Implications |
| 2. | Meski O.; Belkadi F.; Laroche F.; Ritou M.; Furet B. [33] | A generic KM approach towards the development of a decision support system | 2021 | A worldwide approach for KM, starting from the analysis as well as creation of models for structuring the knowledge base and extending to the practical application stage with the utilization of knowledge engineering tools. | Impact of 4IR technologies on KM |
| 3. | Blackburn-Grenon F.; Abran A.; Rioux M.; Wong T. [34] | A Team-Based Workshop to Capture Organizational Knowledge for Identifying AI Proof-of-Value Projects | 2021 | Team-based workshop | Future Directions and Implications |
| 4. | Trevisan A.H.; Lobo A.; Guzzo D.; Gomes L.A.D.V.; Mascarenhas J.[35] | Barriers to employing digital technologies for a circular economy: A multi-level perspective | 2023 | Multiple case studies and literature review concerning nine firms | Challenges and Opportunities |
| 5. | Mtsweni E.S.; Gorejena K. [36] | Team Barriers to Tacit Knowledge Sharing in Software Development Project Teams | 2023 | Interviews and thematic data analysis | Challenges and Opportunities |
| 6. | Bettiol M.; Capestro M.; Di Maria E.; Micelli S.[37] | Disentangling the link between ICT and I4.0: impacts on | 2022 | Questionnaire: entrepreneurs, chief operation officers, or executives overseeing the | Impact of 4IR technologies on KM |

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| | | knowledge-related performance | | operational as well as technological aspects of Italian manufacturing companies. | |
| 7. | Ebekozien A.; Aigbavboa C.[38] | COVID-19 recovery for the Nigerian construction sites: The role of the fourth industrial revolution technologies | 2021 | Interviews and thematic data: twelve construction firms and consultant experts | Challenges and Opportunities |
| 8. | Tortorella G.; Cauchick Miguel P.A.; Frazzon E.; Portioli-Staudacher A.; Kumar M. [39] | Teaching and learning of I4.0: expectations, drivers, and barriers from a KM perspective | 2023 | Exploratory, qualitative study: Semi-structured interviews were conducted with 21 graduate students registered for the I4.0 program. | Challenges and Opportunities |
| 9. | Kafetzopoulos D. [40] | Understanding BMI from I4.0, KM and market uncertainty perspective | 2023 | Interviews: 379 managers and academics | Future Directions and Implications |
| 10. | Anshari M.; Hamdan M. [11] | Understanding knowledge management and upskilling in Fourth Industrial Revolution: transformational shift and SECI model | 2022 | Interviews with a focus group | Future Directions and Implications |
| 11. | Miao M.; Zaman S.I.; Zafar A.; Rodriguez C.G.; Ali Zaman S.A. [41] | The Augmentation of Knowledge Management through Industry 4.0: the case Aviation sector of emerging economy | 2022 | Grey- DEMATEL technique, A seven-scale ranking, as well as sensitivity analysis | Impact of 4IR technologies on KM |
| 12. | Fok-Yew O.; Hamid N.A.A. [42] | The influence of lean practices and leadership on business excellence: Malaysian E&E manufacturing companies | 2021 | Questionnaires: four sub-sectors of the E&E industry | Challenges and Opportunities |
| 13. | Khourshed N.F.; Elbarky S.S.; Elgamal S.[14] | Investigating the Readiness Factors for Industry 4.0 Implementation for the Manufacturing Industry in Egypt | 2023 | Questionnaires: Egyptian manufacturing companies. | Challenges and Opportunities |
| 14. | Jankowska B.; Maria E.D.; Cygler J. [43] | Do clusters matter for foreign subsidiaries in the Era of Industry 4.0? The case of the Aviation Valley in Poland | 2021 | Case study | Challenges and Opportunities |
| 15. | Eslami M.H.; Achtenhagen L.; Bertsch C.T.; | Knowledge-sharing across supply chain actors in adopting Industry 4.0 | 2023 | A single case study was conducted, involving 19 interviews conducted with a German manufacturing | Challenges and Opportunities |

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|---|---|---|---|---|---|
| | Lehmann A. [44] | technologies: An exploratory case study within the automotive industry | | company operating in the automotive sector, along with interviews from five customers and suppliers within the supply chain network of the focal firm. | |
| 16. | Gouda G.K.; Tiwari B. [45] | Talent agility, innovation adoption, and sustainable business performance: empirical evidence from Indian automobile industry | 2022 | Questionnaires: 272 employees of the Indian automobile industry | Challenges and Opportunities |
| 17. | Gupta A.; Kr Singh R.; Kamble S.; Mishra R. [46] | KM in I4.0 environment for sustainable competitive advantage: a strategic framework | 2022 | Interpretive Structural Modelling (ISM) establishes the structural correlations among factors, while Fuzzy MICAMC categorizes the factors relying on driving-dependence value. | Challenges and Opportunities |
| 18. | Cotrino A.; Sebastián M.A.; González-Gaya C. [47] | Industry 4.0 HUB: A collaborative knowledge transfer platform for small and medium-sized enterprises | 2021 | Web-based development | Future Directions and Implications |
| 19. | Rangaswamy U.S.[48] | I4.0 disruption: assessing the need for adaptive capability | 2021 | Author's observations as a practitioner on digital transformation as well as current theoretical frameworks | Future Directions and Implications . |
| 20. | Naruetharadhol P.; Srisathan W.A.; Gebsombut N.; Wongthahan P.; Ketkaew C. [49] | I4.0 for Thai SMEs: Implementing Open Innovation as Innovation Capability Management | 2022 | Second-order analysis: 373 SMEs | Challenges and Opportunities . |
| 21. | Cerezo-Narváez A.; Pastor-Fernández A.; Otero-Mateo M.; Ballesteros-Pérez P.; Rodríguez-Pecci F. [20] | Knowledge as an organizational asset for managing complex projects: The case of naval platforms | 2021 | Case study: Naval platform | Impact of 4IR technologies on KM |
| 22. | Fan I.Y.H.; Shum W.K.F. [50] | Knowledge Management: The Missing Bonding Discipline of STEM Education | 2023 | Semi-structured interviews: STEM teachers, Survey | Challenges and Opportunities |
| 23. | Bucea-Manea-Tonis R.; Kuleto V.; Plojović Š.A.; Beteringhe A.; Ilić M.P. [51] | Securing Big Data for Knowledge Management in a Circular Economy | 2022 | Case study | Impact of 4IR technologies on KM |

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|---|---|---|---|---|---|
| 24. | Poma L.; Shawwa H.A.; Rau C. [4] | Industry 4.0 and Internal Knowledge Management: The case of Corporate Academies in Emilia-Romagna region | 2021 | Research and survey: 29 Italian Corporate Academies with regard to the manufacturing sector | Future Directions and Implications |
| 25. | Csizmadia T.; Obermayer N.; Bogdány E.; Purnhauser P.; Banász Z. [52] | Examining Industry 4.0 through the lens of human resource and knowledge management: Implications for SMEs | 2023 | Questionnaires: 122 participation of Hungarian SMEs leaders | Impact of 4IR technologies on KM |
| 26. | Aghimien D.; Aigbavboa C.; Matabane K. [53] | Dynamic capabilities for construction organizations in the Fourth Industrial Revolution era | 2023 | Questionnaires | Challenges and Opportunities |
| 27. | Pietruszka-Ortyl A.; Ćwiek M.; Ziębicki B.; Wójcik-Karpacz A. [54] | Organizational culture as a prerequisite for knowledge transfer among it professionals: The case of energy companies | 2021 | Systematic analysis with regard to the structured questionnaires, expert evaluation, as well as scientific literature | Challenges and Opportunities |
| 28. | Cárcel-Carrasco J.; Gómez-Gómez C. [55] | Qualitative analysis of the perception of company managers in knowledge management in the maintenance activity in the era of Industry 4.0 | 2021 | Conducting on-site research and observations, along with semi-structured interviews involving company directors and maintenance managers from a wide range of sectors, be it industrial or service-oriented. | Challenges and Opportunities |

### *4.1 The Impact of 4IR Technologies on KM Practices*

The 4IR technologies' impact with regard to KM is critical to modern business and project management. 4IR technologies were categorized into three groups: smart construction site, simulation and modelling, as well as digitization and virtualization [38]. These technologies involve handling vast and diverse data and knowledge, often called big data [33]. Additionally, complicated projects that demand integration with regard to multiple sources of information as well as knowledge also benefit significantly from 4IR technologies. Organizations must continually integrate digital technology innovations into their production processes to remain competitive. In this case, efficient requirements management is a crucial asset for project stakeholders. Streamlining requirements management can lead to several advantages, including meeting customer needs more effectively, shortening project durations, reducing costs, optimizing resources, and enhancing flexibility. However, it is worth noting that effective requirements management is closely intertwined with KM [20].

In Small and Medium-sized Enterprises (SMEs), the 4IR technologies implementation is shown to support human workforces. Collaborative social media, as well as technologies, were implemented to improve knowledge sharing within SMEs, emphasizing the role of these technologies in facilitating

knowledge transfer. Notably, the main purpose of utilizing 4IR technologies in SMEs does not revolve around knowledge storage but rather focuses on workforce empowerment and efficiency [52]. Furthermore, a positive correlation exists between ICT as well as 4IR technologies. This connection involves the degree of technology adoption and different categories of technologies, including web-based, manufacturing ICT, management, as well as customization, operation, and data-processing 4IR technologies. These technologies are crucial in impacting knowledge-related performances across different aspects, including product and process improvements, job learning, improved product-related services, as well as raised customer involvement [37].

### *4.2 Challenges and Opportunities in 4IR KM*

Navigating the challenges of KM in the 4IR era is critical for organizations. Aghimien [53] establishes that creating the right capabilities is critical for organizations to thrive amidst the rapid technological changes brought by the 4IR. These capabilities include technology governance and the development of new resources and processes to enhance competitiveness and transform service delivery, particularly in the construction sector. However, several challenges hinder effective KM in the 4IR context, as noted by Ebekozien [38]. These challenges include reluctance to adopt new technologies, inadequate KM practices, high implementation costs, as well as resistance to change within organizations. These obstacles underscore organizations' difficulties in effectively harnessing and managing knowledge in the 4IR landscape. Furthermore, Mtsweni and Gorejena [36] identified seven team-oriented barriers that can impede KM efforts, including communication, trust, characteristics, cohesion, dispersion, orientation, and team culture. These barriers highlight the importance of addressing interpersonal and collaborative aspects within teams to facilitate effective KM as well as sharing. In describing the challenges of cooperation and collaboration in the 4IR era, Ebekozien [38] suggests that Thailand’s SMEs utilize open innovation as a specific approach. Open innovation is extensively applied to create new shared value through innovation, indicating the need for innovative solutions to overcome the hurdles of collaboration in the rapidly evolving 4IR landscape.

With the challenges at hand, organizations have substantial opportunities to strengthen their KM practices in the 4IR era. Eslami [44] has identified key knowledge-sharing approaches that guide KM adoption with regard to the 4IR context. These strategies, encompassing knowledge-sharing via principles, the upstream flow of knowledge, strategic positioning, and relevance to applications, are shaped by a combination of factors related to the company and relationships. This insight offers organizations structured methods to effectively manage knowledge in the 4IR era, aligning their KM strategies with the evolving technological landscape. Furthermore, Gouda and Tiwari [45] had emphasized the significant impact of various factors regarding innovation adoption as well as sustainable business performance concerning the 4IR landscape. Factors such as KM, a climate with regard to innovation, learning agility, as well as internal corporate communication are crucial in driving innovation adoption, which, in turn, positively influences sustainable business performance. Ambidextrous leadership demonstrated an insignificant relationship regarding innovation adoption, the overall findings underscore the potential of KM to drive innovation and long-term success in the dynamic 4IR environment. Thus, organizations can capitalize on these insights by prioritizing the development of a knowledge-friendly culture, digital infrastructure, employee training, and organizational culture catered to the needs of knowledge workers, ultimately equipping them with essential skills and abilities for effective KM in the 4IR era [40-42].

### *4.3 Future Directions and Implications for KM in the 4IR Era*

In the context with regard to KM within the 4IR era, Montoya-Quintero *et al.,* [32] emphasized the significance of focusing on critical variables related to quality management and KM. These variables have broad applicability across various types of organizations that have implemented 4.0 technologies. It underscores the importance of these foundational aspects in the 4IR landscape. Kafetzopoulos [40] sheds light on the complex interplay between 4IR capabilities, KM capabilities, as well as business model innovation. The research emphasizes that KM capabilities refer to a mediating role in the connection between 4IR capabilities and the innovation of business models. Additionally, it indicates that 4IR capabilities have a more pronounced effect on KM capabilities for companies operating in uncertain markets. Conversely, the impact with regard to KM capabilities on business model innovation is less significant in highly uncertain market conditions. This implies that managers should prioritize investments in cutting-edge technology to gain knowledge and capabilities, all the while thoughtfully assessing how the knowledge gained from 4IR contributes to the development of innovative business models.

Additionally, Cotrino *et al.,* [47] emphasizes the challenges faced by SMEs during their transformation to 4IR. They emphasize the threats connected with a deficiency in understanding and underscore the necessity for enhanced 4IR KM and transfer methods. The authors encourage the development with regard to collaborative knowledge transfer platforms or hubs tailored to the needs of SMEs as a solution to bridge this gap. Furthermore, Anshari and Hamdan [11] underscored the demand for critical skills in the 4IR landscape, including social responsibility, social skills, critical thinking, creativity, project management, collaborative innovation, problem-solving, as well as complex decision-making. Note that these skills are essential in navigating the evolving scenarios of the 4IR. However, the authors also identify emerging research trends such as the 4IR skill gap, collaborative innovation, digital fluency, technostress, intuitive decision-making, machine knowledge, and societal systems that require further exploration in the context of KM and the 4IR.

## 5. Discussion and Conclusion

The Fourth Industrial Revolution (4IR) has brought about transformative changes across various industries, fundamentally altering our way of life and organizational operations. The widespread adoption of advanced technologies within 4IR has led to the generation of vast and heterogeneous data and knowledge, necessitating effective management to enable their reuse [33]. The era of big data with regard to 4IR poses challenges in knowledge transfer and administration, making Knowledge Management (KM) increasingly complex. Nevertheless, 4IR technologies promise to enhance manufacturing performance through the management as well as creation with regard to new knowledge, both within organizations and through customer interactions, and have proven to be successful platforms for communication and collaboration within teams [38]. As an intangible asset, knowledge can significantly enhance employee and organizational effectiveness. Yet, limited research has centered on upgrading KM systems within the 4IR environment [46]. In the domain of industrial maintenance, the importance of knowledge, particularly based on personal experience, is paramount in achieving the excellence that organizations strive for [55]. Unfortunately, KM in this field often receives inadequate attention, is relegated to a lower priority level, or is even overlooked entirely. The digital disruption by 4IR has created a heightened demand for skilled professionals who are accustomed to innovation in a volatile as well as rapidly changing environment [45].

In the Fourth Industrial Revolution (4IR) era, Knowledge Management (KM) is crucial due to its role in driving innovation, enhancing decision-making, and facilitating global collaboration. The

integration of 4IR technologies like Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics significantly elevates the importance of KM. It enables organizations to effectively manage and utilize vast data, adapt to evolving skill sets, and optimize operations. KM is also essential in addressing the ethical and compliance challenges brought by new technologies, and in cultivating a learning culture vital for staying competitive in a rapidly changing digital landscape. By leveraging KM, organizations can navigate the complexities of 4IR, fostering continuous learning and adaptation, and maintaining a competitive edge in a dynamic and interconnected world.

Organizations must implement digital leadership styles with robust KM practices, foster climates conducive to innovation, promote learning agility, as well as improve corporate communication with regard to their talent development strategies. These elements are essential to enhance strategic capabilities and reduce operational expenditures. Adopting KM practices becomes a critical strategy in equipping individuals and organizations with the skills and capabilities needed to thrive in the 4IR era [11]. KM provides competitive advantages and serves as a means for organizational survival by improving core capabilities or producing new ones significant in the rapidly changing landscape of the 4IR. By facilitating individuals' utilization of their existing core capabilities or generating new ones, KM supports upskilling to fulfil current as well as future skill requirements. In essence, KM enhances an organization's talent-driven learning strategy, allowing individuals to adapt faster and obtain sustainable competitive advantages in a fast-paced and dynamic environment.

As conclusion, this study reveals several research gaps in the existing literature, offering opportunities for comprehensive exploration and development. One significant area is the integration of traditional KM practices with 4IR technologies like Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics, to enhance organizational knowledge sharing and innovation. Additionally, there is a need to define effective leadership styles for 4IR-enabled organizations, focusing on the traits and skills necessary for success in this new era. The complexity of human-machine interactions in KM, particularly in the context of knowledge creation and sharing, is another area that requires further study to optimize efficiency and innovation. Moreover, the management and utilization of the vast data generated by big data and IoT technologies present a challenge that research could address by developing methods for extracting and integrating this knowledge into decision-making processes. The cultural and ethical implications of integrating advanced technologies in KM also warrant investigation, especially regarding how different cultural contexts affect the adoption of these technologies and the ethical considerations of AI and automation. Finally, the evaluation of KM effectiveness in the 4IR era calls for the development of new metrics and evaluation methods, providing innovative tools and frameworks to measure the impact of 4IR technologies on KM effectiveness and organizational performance. Addressing these gaps will not only enrich the KM literature but also provide practical insights for organizations navigating the complexities of the 4IR.

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