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ORIGINAL PAPER

A SYSTEMATIC LITERATURE REVIEW ON ADVANCES, TRENDS AND CHALLENGES IN PROJECT MANAGEMENT AND INDUSTRY 4.0

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ABSTRACT. Background: This review examines the concept of Industry 4.0, underscoring its genesis, integral technologies, implementation hurdles, and the imperative nature of sustainability. The successful transition to Industry 4.0 necessitates the comprehensive understanding and efficacious management of a multitude of intricate variables.
Methods: A Systematic Literature Review was undertaken and coupled with a bibliometric analysis to probe into the current status of Project Management and Industry 4.0 research. The stringent procedures employed encompassed a literature search, selection based on precise inclusion/exclusion criteria, and an in-depth analysis, culminating in the identification of future research opportunities.
Results: The findings reveal a burgeoning interest in project management and Industry 4.0, the dominance of conference papers and scholarly articles, an interdisciplinary approach to project management and Industry 4.0, global participation, and notable authors in the field. Moreover, content analysis facilitated the delineation of study topics concerning the transformation of the project manager's role in Industry 4.0, the adoption and utilization of digital technologies in project management during the Industry 4.0 era, success determinants for project management in the Industry 4.0 epoch, the adaptation and evolution of project management in light of Industry 4.0, the influence of digitalization on project management and sustainability, strategic project management methodologies in the context of Industry 4.0 technologies, and barriers impeding the implementation of Industry 4.0 technologies.
Conclusion: This study clearly shows that there is a rising interest in project management and Industry 4.0, with a specific emphasis on the application of digital technologies. It underscores the pivotal role of education and training in these novel technologies. Crucial success factors include maturity in project management, effective training, and adeptness in implementing Industry 4.0 components. The review uncovers opportunities for future research that could aid organizations and professionals in navigating the progressively more digitized landscape of their respective fields.

Keywords: Project Management, Industry 4.0, Digital Technology, Systematic Literature Review.

INTRODUCTION

Industry 4.0, a term first introduced in Germany in 2012, represents a strategic initiative to capitalize on emergent technological advancements, including cyber-physical systems, the Internet of Things (IoT), future industrial sectors, real-time collaboration, and the digitalization of manufacturing. At the inception of the Fourth Industrial Revolution or Industry 4.0, Enterprise Resource Planning (ERP) evolved as a vital component encapsulated within the Future of Factories

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(FoF) concept, which characterizes the technologies aligned with Industry 4.0.

Various studies have delved into multiple facets of Industry 4.0. For instance, Jardim et al. [2016] pinpointed the principal challenges and innovations pertaining to intelligent industrial production. Concurrently, Haddara & Elragal [2015] appraised the preparedness of ERP systems for FoFs, while Jin et al. [2017] fueled the discussion on process design management in the realm of human resources within a globalized context. This has fostered the emergence of virtual spaces in workplaces for customer interaction, bespoke on-demand manufacturing, and the circular economy. The goal of Industry 4.0 is to enable the integration and synergy of physical and digital realms. Ghobakhloo [2020] delivered a holistic perspective of the constituent elements of Industry 4.0 and their interdependencies, including smart project management, smart stakeholders, smart supplies, smart environmental sustainability, smart warehouses, smart products, smart customer integration, smart factories, and smart manufacturing [Valentin et al., 2018].

Kiraz et al. [2020] detailed nine elements influencing the current trends in Industry 4.0, among which market and consumer access is deemed most critical. These components include market and consumer access, data protection, processing and collective expertise, organizational culture, value chain and processes, IT architecture, risk and security, business models, products and services, data integration for analytics, leadership strategy, culture, and management. Within the prevailing competitive global climate, market and consumer access is perceived as the most influential element.

Even though Industry 4.0 technologies exist, their deployment relies on numerous variables, paradigm shifts, and changes in approach. If sustainability is not the central focus, the 4.0 revolution may lose its course and intensify environmental degradation and resource depletion. The true potential of Industry 4.0 can be realized when supply chains, intelligent machines, and specialized human resources are interconnected within a unified network, operating in real time within a circular economy [Ghimire et al., 2017]. Ozkan et al. [2020] illuminated the current challenges faced during the transition to Industry 4.0. Majumdar, Garg, & Jain [2020] recognized similar barriers in the textile and apparel industry, encompassing the lack of workforce training, inadequate understanding and commitment from top executives, insufficient government support and policies, gaps in research and development, high implementation costs, fear of change and failure, and poor integration and compatibility. Bag et al. [2020] documented the modifications required for the adoption of Industry 4.0. Ambitious plans like China's "Made in China 2025" aim to shift from the mass production of standardized goods to high-tech customizable products. In Germany, sustainable energy use, energy audits, management and monitoring systems, sales control, and energy integration are viewed as critical in the Industry 4.0 environment.

The purpose of this article is to offer an extensive overview of the nascent features and trends of Industry 4.0, highlighting important aspects related to its implementation while pinpointing potential advantages and challenges. Comprehending how to navigate this intricate environment is crucial given the complexities of implementing Industry 4.0 [Zhu & Mostafavi, 2017]. This article also scrutinizes the project management approach in engineering and probes into a variety of technological tools for implementation and integration. A successful transition to Industry 4.0 is contingent upon numerous variables, each one possessing its unique challenges and opportunities. Acknowledging these factors will enable industries to better equip themselves for this transformative shift, thereby enhancing efficiency, productivity, and sustainability [Benešová et al., 2019]. The insights and strategies elicited from this research review could serve as beneficial guidelines for corporations aiming to smoothly transition to Industry 4.0.

METHODOLOGY

To ensure credibility in research addressing a given problem, it is vital to utilize a methodology that comprises a series of transparent procedures [Kraus et al., 2022]. The Systematic Literature Review (SLR) has gained recognition as a gold standard in locating, selecting, and synthesizing published materials with the aim of addressing a pre-defined research question [Snyder, 2019]. Moreover, this methodology serves diverse functions ranging from charting the intellectual territory to pinpointing future research opportunities and shaping pertinent research questions [Borrego et al., 2014]. This is achieved through a stringent methodology that incorporates formulating the research question, defining inclusion and exclusion criteria, conducting literature search and selection, extracting and synthesizing data, assessing study quality and risk of bias, and ultimately, communicating and disseminating results [Snyder, 2023; Perez, 2019].

In alignment with the aforementioned, we applied the SLR methodology to examine the extant literature on Project Management and Industry 4.0. Furthermore, we undertook a bibliometric review as it provides the advantage of handling a substantial volume of published works and scrutinizing them to suggest future directions [Linnenluecke et al., 2019]. To assure the objectivity and reliability of the bibliometric review, a review protocol was devised, as shown in Table 1 [Kraus et al., 2022]. Figure 1 delineates the stages followed to execute the SLR, the specifics of which are described subsequently.

Table 1. Search protocol.

Protocol	**Description**
Database	Scopus, Web of Science (WOS)
Search item	Title, keywords and abstract
Keywords	**PM:** "project management*" OR "project management 4.0" **I4.0:** "Industry 4.0" OR "digital technolog*" OR "fourth industry" OR "I4.0"
Inclusion criteria	- Type of document: article, review, conference paper, book chapter, conference review - Language: English and Spanish - Knowledge area: Engineering, Management, Computer Science, Decision Sciences and Social Sciences.
Exclusion criteria	- Not aligned with Projects and Industry 4.0 - Written in a language other than English - Duplicates (same articles found in different databases)
Analysis tool	VOSViewer for bibliometric analysis
Data analysis	Bibliometric and evolution analysis of the use of digital tools and I4.0 in project management.

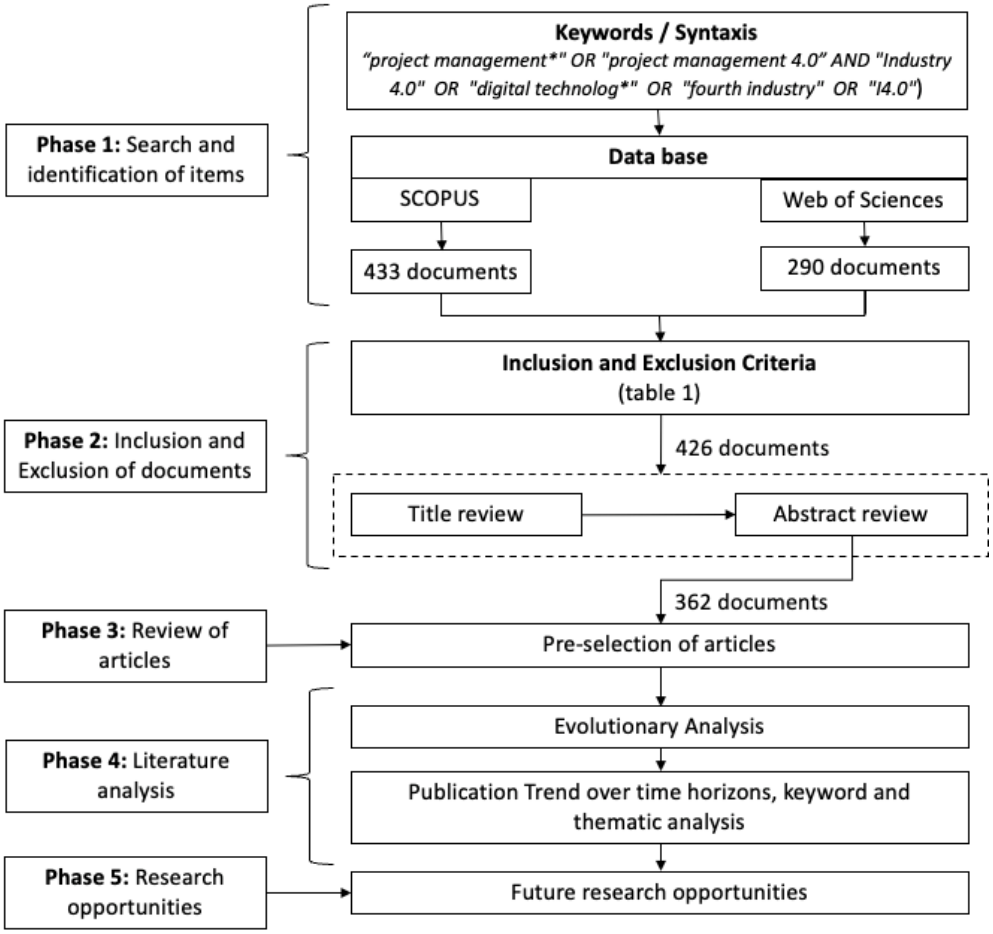

Fig. 1. SLR search methodology.

Phase 1: Search and identification of documents

Articles for review were extracted from the recognized academic databases Scopus and Web of Science. The keywords and syntax used were (TITLE-ABS-KEY ("project management*" OR "project management 4.0") AND TITLE-ABS-KEY ("Industry 4.0" OR "digital technolog*" OR "fourth industry" OR "I4.0"). This search was conducted during May 2023.

Phase 2: Inclusion/Exclusion Criteria

The keyword search led to the identification of 487 articles in Scopus, 290 articles in Web of Science. We applied the inclusion and exclusion criteria detailed in Table 1 to exclude unrelated articles and duplicates. This selection reduced the number to 426 articles. In addition, in line with the topic, we performed a selection of full abstracts to include the most relevant articles for the review. As a result, we shortlisted 362 articles for review and analysis.

Phase 3: Review of Shortlisted Articles

The shortlisted articles were critically analyzed and reviewed to understand the state of the research, development, and application of the I4.0 concept in project management to understand the progression of any cutting-edge research, salient issues, and evolution of the field.

Phase 4: Literature Analysis

Bibliometric and thematic analyses were conducted on the shortlisted articles. The bibliometric analysis allowed us to examine publication trends (by year and country), citation patterns, and keywords. We used VOSviewer© software to perform a keyword analysis to

determine the frequency of co-occurrence of keywords. In addition, we identified, analyzed, and discussed the most salient PM and I4.0 themes.

Phase 5: Research Opportunities

Through the literature review, we identified research gaps. Based on these gaps, we defined the research opportunities presented in this section.

RESULTS AND DISCUSSION

Bibliometric analysis

Descriptive analysis was conducted to summarize relevant information about the publications shortlisted for this review study. The descriptive analysis provided a detailed understanding of publication trends over time, geographic locations, areas of expertise, and document types. In addition, we conducted a keyword analysis to gain insight into the most salient concepts discussed in the existing literature.

Figure 2 presents the publications of PM and I4.0 research over time. A total of 362 papers published between 1997 and May 2023 were identified. Interest in this field of knowledge was minimal until 2014. During the first few years, between 1 and 4 documents were published. In 2004, 10 publications were reported. After this year, until 2007, the literature begins to show a significant increase in publications. Then, in the years 2010 to 2022, 70% of the 362 documents reviewed were published.

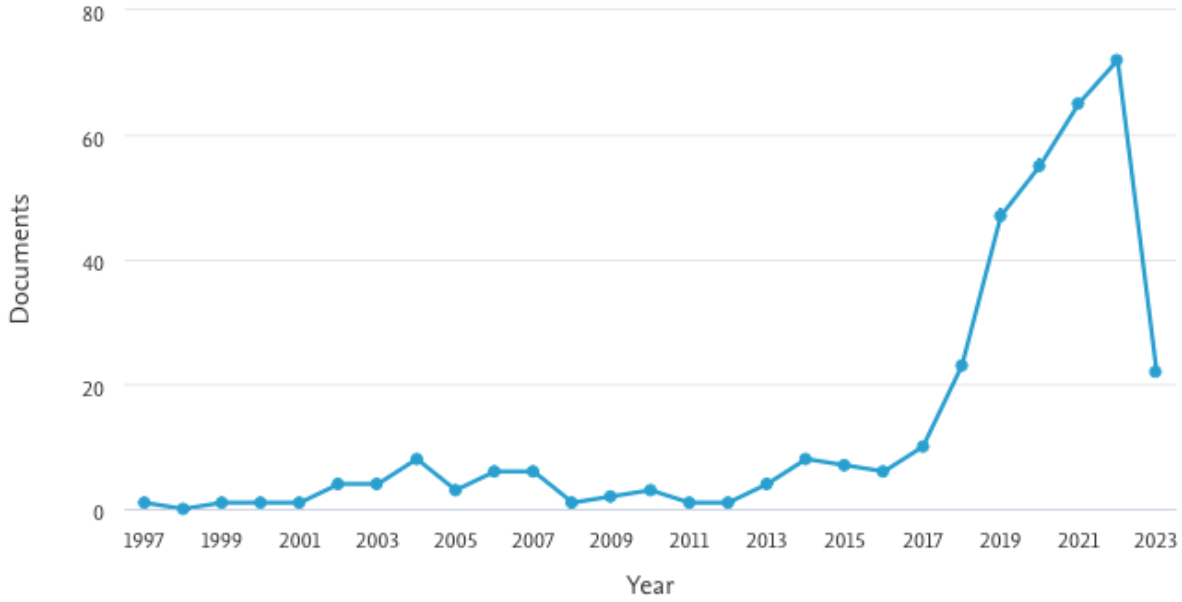

Fig. 2. Publications by year.

Figure 3a shows the distribution of the documents with respect to the type of document. In this area of study, conference papers predominate in more than half of all the publications. However, it is evident that scientific articles take a large share, with 30.4%, followed by reviews, with 6.6%. This represents a great opportunity to publish scientific studies in high impact journals. Figure 3b presents the distribution of documents by area of knowledge. This subject area is of interest to various areas of study, primarily from engineering, to materials science and chemical engineering.

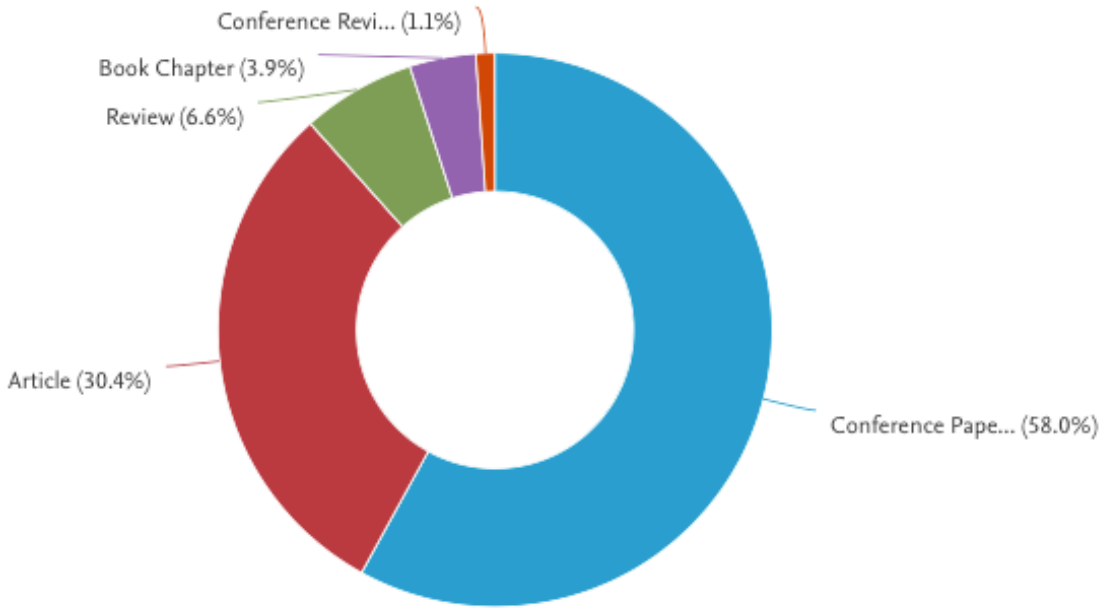

Fig. 3a. Publications by type of document.

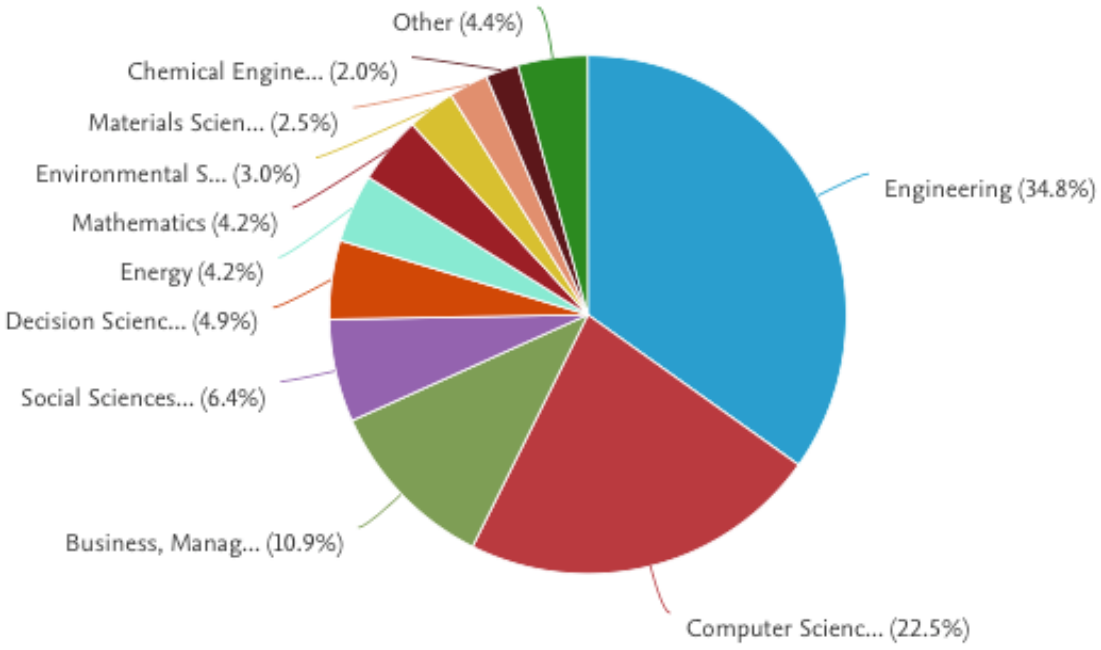

Fig. 3b. Publications by area of knowledge.

Contributions from 79 countries were counted in the studies analyzed. Figure 4 shows the 10 countries that published two or more articles. Authors from the United Kingdom and the United States contributed the most (87 studies), followed by China (40), Germany (27), and Australia (20).

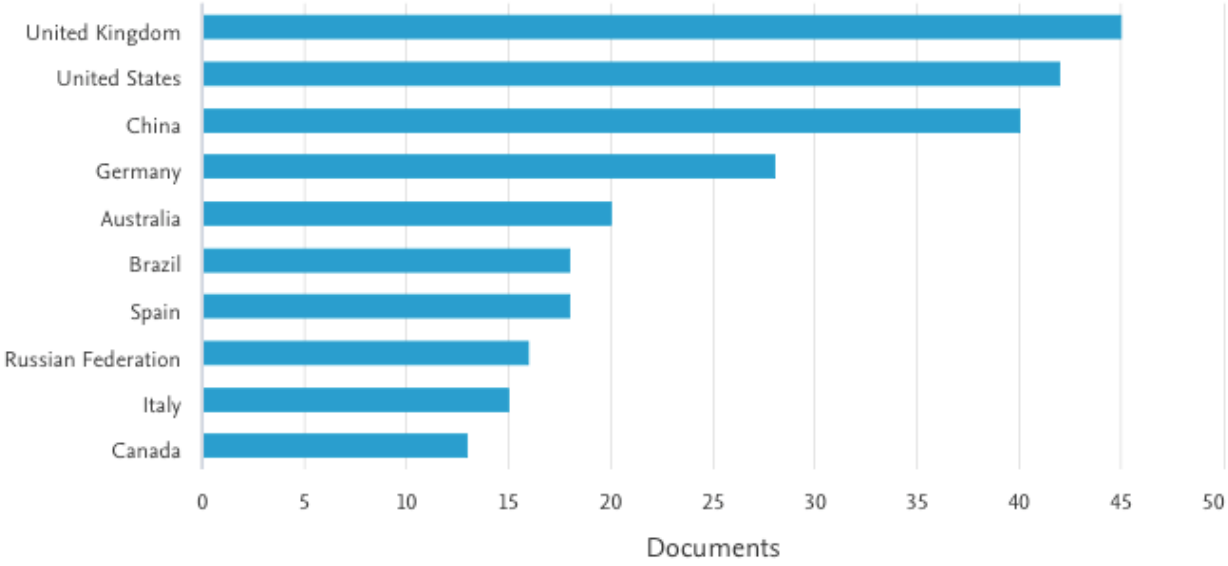

Fig. 4. Top 10 publications by country.

When analyzing the journals, it was found that the 362 documents were published in 232 different sources. In terms of refereed journals, Sustainability contributed 11 papers; however, the journal with the most citations is the International Journal of Production Research, with 202 citations in 1 article, followed by the Journal of Cleaner Production, with 3 articles. Table 3 presents the contribution of the top 10 journals.

Table 2. Top 10 journals with the highest number of publications.

Journal	**Documents**	**Citations**
Sustainability (Switzerland)	11	85
Automation in Construction	4	70
Engineering, Construction and Architectural Management	3	37
Journal of Cleaner Production	3	199
Journal of Information Technology in Construction	3	48
Journal of Manufacturing Technology Management	3	16
Operations Management Research	3	19
Sensors	3	18
Business Process Management Journal	2	15

Citation analysis

We performed a citation analysis of the 263 pre-selected studies. Table 3 shows the ten most cited papers focusing on the aspect of resilience within PM and I4.0. The reviewed papers have received a total of 2,911 citations (as of May 2023), with an average of 8 citations per article. It is notable that 55% of the citations correspond to article-type documents. It is evident that many highly cited papers have been published in the last 4 years. This could indicate the boom and interest in the implementation of I4.0 technologies in PM.

Table 3. Most cited documents.

Article	Citation	Average per year
Moeuf et al. (2020)	202	101
Bag et al. (2021)	147	147
Whyte et al. (2016)	120	20
Benner (2009)	90	6.92
Muñoz-la et al. (2021)	63	63
Pärn et al. (2018)	52	13
Chofreh et al. (2020)	52	26
Poirier et al. (2017)	51	10.2
Hassan (2013)	48	5.33
Vrchota et al. (2021)	48	48

Main authors.

Table 4 shows that Prof. Pellerin has contributed the most, with 6 publications on the subject. In terms of citations, Prof. Pal R. has been the most cited author, with 204 citations in only 1 published paper in the study area. However, among the authors with more than 1 published paper, author Liu Y. has 104 total citations and 52 citations per paper, followed by Prof. Jayaram, with a total of 101 citations and an average of 50.5 citations per paper.

Table 4. Main authors.

Author	Articles	Citation	Average per citation and article
Pellerin R.	6	248	41.3
Li Y.	5	13	2.6
Matt D.T.	5	31	6.2
Deschamps F.	3	5	1.7
Li T.	3	3	1.0
Marnewick A.L.	3	40	13.3
Marnewick C.	3	40	13.3
Narvel Y.A.M.	3	13	4.3
Oke A.E.	3	2	0.7
Perrier N.	3	38	12.7
Pellerin R.	6	248	41.3
Li Y.	5	13	2.6

Keyword analysis

Figure 5 presents the most used keywords and the co-occurrence between them. Four clusters of keywords of different colors are formed in the network. It is evident that project management, industry 4.0, digital technologies, construction industry, architectural design, information management, digital transformation, construction, decision making, life cycle, construction projects, engineering education,

building information modeling, digital technology, human resource management, sustainable development, artificial intelligence, information systems, internet of things, BIM, competition, construction management, embedded systems, and information theory are the most used keywords in the documents. This indicates that these are some of the critical issues that have been addressed in PM and Industry 4.0 studies.

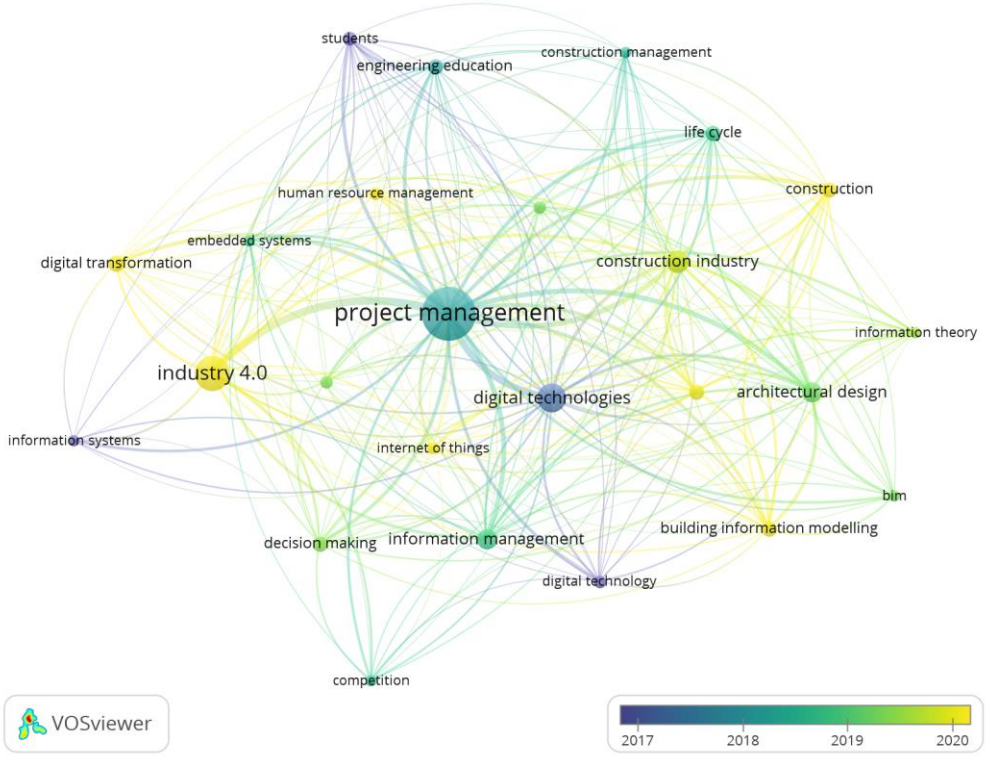

Fig. 4. Co-occurrence of keywords.

Content Analysis

A content analysis was carried out on the pre-selected articles to explore the progress of the studies within the FP and I4.0. The thematic lines that have been addressed by the different studies analyzed in the FP and I4.0 are detailed below.

Refashioning the Role of the Project Manager in Industry 4.0

The refashioning of the project manager's role in the era of Industry 4.0 entails alterations and demands that this role must confront amidst the digital revolution. The surveyed literature underscores education as a cardinal factor. Abushammala [2019] emphasizes the significance of university-level education in project management, specifically within civil engineering. The application of active learning methodologies and digital technology in a flipped classroom environment can enhance student performance. Amri et al. [2021] assert that academic and professional qualifications are pivotal in adapting to new Industry 4.0 methodologies. They further underscore the necessity for a heightened focus on the social dimension within sustainability studies related to Industry 4.0 as this influences the role of the project manager in construction [Albarracin-Rodriguez et al., 2023].

Various authors highlight the new skills and competencies necessary for the Industry 4.0 era. Ada et al. [2021] identify project management as the most crucial skill in the Industry 4.0 era, followed by financial management, technology skills, digital literacy, innovation, and creativity. Cabeças [2022] emphasizes the importance of

outlining the appropriate profile of the project manager to confront this new reality, accentuating the relevance of new technologies and hybrid approaches to project management. Marnewick and Marnewick [2020a] contend that future project teams will incorporate both human and non-human entities (e.g., AI-enabled robots), necessitating novel competencies, especially in critical thinking and problem-solving.

Based on the refashioning of the project manager's role in Industry 4.0 and the research conducted by the cited authors, several prospects for future research have been identified:

- Evolution of project management in Industry 4.0.
- Impact of education on the reshaping of the project manager's role.
- Integration of sustainability into project management in Industry 4.0.
- Management of mixed project teams (human and non-human).
- Identification of competencies required for project management in Industry 4.0.
- Influence of social factors on project management in Industry 4.0.

Adoption and Application of Digital Technologies in Project Management in the Industry 4.0 Era

The adoption and application of digital technologies in project management within the era of Industry 4.0 are swiftly revolutionizing traditional operational methods. The referenced sources provide various case studies and perspectives on how these technologies are being incorporated within the construction sector and other industries. The awareness and employment of Cyber-Physical Systems (CPS) within Nigeria's construction industry are detailed by Adeosun & Oke [2022], identifying specific technologies as the most adopted within the construction sector. Attencia & Mattos [2022] scrutinize technology adoption within smart asset management and discuss factors that may influence the degree of technology adoption in asset management.

Atuahene et al. [2022] explore the benefits of Big Data within the construction industry, while Blackburn-Grenon et al. [2021] present a team-oriented workshop to harness organizational knowledge in identifying relevant artificial intelligence (AI) projects. Jasim et al. [2020] focus on the application of Artificial Neural Networks to enhance accuracy in estimating earned value indices in Iraqi road construction projects.

Research opportunities discerned from the information provided include:

- Comparative studies on the adoption of Cyber-Physical Systems (CPS) across different industries.
- Factors influencing technology adoption within smart asset management.
- Applications and benefits of Big Data in project management.
- Training and skills development for the adoption of AI technologies.
- Employment of Artificial Neural Networks in project estimation.
- Identification and surmounting of barriers to the adoption of digital technologies in project management.
- Case studies on the application of digital technologies in project management in the era of Industry 4.0.

Critical Success Factors for Project Management in the Industry 4.0 Era

This subject area investigates the pivotal elements that contribute to the success of digitization endeavors in the Industry 4.0 era while also examining the correlation between project management maturity, Industry 4.0 components, and business excellence. Fajsi et al. [2022] underscore the significance of project management maturity in attaining business excellence in the Industry 4.0 context. Kanski & Pizon [2023] propose that Industry 4.0 components can serve as indicators of project success, particularly in the implementation of digital enhancements. Moeuf et al. [2020] pinpoint the dearth of experience and a short-term strategic approach as potential risks for SMEs adopting Industry 4.0, emphasizing the

essential role of training for project success. Pozzi et al. [2023] and Romagnoli et al. [2022] concentrate on the critical factors for the successful implementation of Industry 4.0 and suggest evaluation methodologies that focus on the external dimensions of the project, such as functionalities and the quality of outcomes. Contrarily, Vrchota et al. [2021] identify financing as a key factor for the sustainability of Industry 4.0 projects, linking the benefits of Industry 4.0 to sustainability. Opportunities for future research based on this discourse include:

- Analysis of the correlation between project management maturity and business excellence.
- Identification of Industry 4.0 components that impact project management success.
- Research on the critical elements for the successful adoption of Industry 4.0 within SMEs.
- Examination of the influence of training and skills development on the success of Industry 4.0 projects.
- Research on the success and sustainability factors of Industry 4.0 projects.
- Development of project evaluation methodologies in the context of Industry 4.0.
- Research on the correlation between Industry 4.0 project management and sustainability.

The Adaptation and Evolution of Project Management in the Context of Industry 4.0

The reviewed sources provide a multitude of perspectives on the adaptation and evolution of project management in the context of Industry 4.0. Aliev et al. [2007] and Kianpour et al. [2021] stress the necessity of integrating digital technology to augment efficiency and reliability in projects. Drobik [2000] and Piccione [2021] underscore the importance of effective planning and strategy, differentiating between E-business and E-commerce, and offering recommendations for strategy development. Frederico [2021], Gentner [2016], and Richard et al. [2021] propose frameworks for tailoring project management to the Industry 4.0 context, encompassing the use of agile and adaptive approaches, as discussed in the works of Kohnová et al. [2023] and Rane & Narvel [2021]. Lastly, Kinelski [2020] and Kianpour et al. [2021] explore digital transformation and continuous improvement as elements driving change in project management within Industry 4.0.

Opportunities for future research informed by these findings include:

- Best practices for integrating digital technology into project management.
- Effective planning and strategy approaches within the context of Industry 4.0.
- Tailoring project management to fit the Industry 4.0 landscape.
- Adoption of agile and adaptive methodologies within project management.
- Exploration of digital transformation and continuous improvement within project management.
- Case studies on the evolution of project management within the Industry 4.0 era.
- Training and competency requirements for project management within Industry 4.0.

Implications of Digitalization for Project Management and Sustainability

The progression of digitalization and Industry 4.0 continues to exert a significant influence on project management and sustainability, impacting professional practices, necessary competencies, and sustainability outcomes. Li et al. [2022] explore the way adoption of digital technologies, such as Building Information Modeling (BIM) and the Internet of Things (IoT), can enhance economic, environmental, and social sustainability within construction projects. They emphasize the crucial role of stakeholder collaboration in this context. Low et al. [2021] expose an escalating divergence between employer expectations and graduate skills in the Industry 4.0 epoch, proposing that alongside technical competencies, soft skills have grown in importance to adapt to novel work methodologies.

Marnewick & Marnewick [2020b] scrutinize the manner in which the Fourth Industrial Revolution is modifying the methods

project teams utilize and manage. They contend that leadership styles must evolve, with servant leadership proving more apt in the context of implementing fresh technologies. Marnewick & Marnewick [2022] dissect the impact of digitization on IT project management, with their bibliometric analysis suggesting that while technologies are being employed to optimize project management processes, the discipline of project management has yet to be completely digitized. Olsson et al. [2021] inspect the application of 3D printing within construction projects, an innovation emblematic of Industry 4.0. While this technology can enhance the efficacy of construction processes, it also presents challenges, particularly concerning cost-efficiency. Vărzaru et al. [2022] evaluate how digitization is impacting project management, marketing, and decision-making processes, observing high acceptance of digitization in decision making, largely owing to the role of artificial intelligence in repetitive decision-making tasks. Walker & Lloyd-Walker [2019] investigate how shifts in the work environment are modifying the nature of project work and the requisite skills, predicting that non-routine work roles will become more interesting and rewarding, whereas routine roles are likely to be supplanted by advanced digital technology.

These studies highlight the necessity to adapt and evolve in response to the burgeoning influence of digitization and Industry 4.0 on project management and sustainability [Soledispa-Cañarte et al., 2023]. Both technical and soft skills, coupled with new leadership styles and collaboration methodologies, are increasingly crucial to navigate this novel landscape successfully [Albarracin-Rodriguez et al., 2023]. However, further research is required to thoroughly comprehend the implications of these trends and to guide practitioners and organizations as they adjust to them. Prospective research opportunities include:

- Digital technologies and sustainability.
- Skills for the digital age.
- Leadership styles in managing digitized projects.
- Comprehensive digitization of project management.
- Implementation of technological innovations and associated challenges.
- Digitization and decision-making.
- Changes in the work environment and their implications for project management.

Project Management Strategies and Industry 4.0 Technologies

The studies discussed herein delve into the interplay between project management and Industry 4.0 technologies and their impact across various industries, including the AEC (Architecture, Engineering, and Construction) sector and the brewing industry. Khodabakhshian A. et al. discuss how AI and machine learning techniques are being harnessed to improve risk management in construction projects, thus facilitating digitization and process optimization. Lima et al. [2023] posit that Lean project management (LPM) and soft skills are essential in tackling the uncertainties accompanying Industry 4.0, emphasizing the value these add to organizations in the digital transformation era. Sembin et al. [2021] investigate project management strategies in the context of digital transformation in Kazakhstan, underscoring the importance of effective implementation of Industry 4.0 innovations for sustainable development. Vrchota & Řehoř [2021] accentuate the need for innovation within project management and organizations, noting that effective project management can expedite change and innovation seamlessly and without errors. Wang [2015] elucidates how Industry 4.0 technologies are enhancing energy management in the brewing industry, particularly focusing on precise temperature control to optimize beer flavor. Whyte et al. [2016] discuss change management practices in organizations that handle large complex projects and depend on digital technologies, emphasizing the importance of configuration management in these contexts. Sipes [2006] discusses the use of the Global Information System (GIS) as a digital tool to determine geospatial data in design processes in architecture and interior design.

Barriers and Challenges Encountered in the Adoption of Industry 4.0 Technologies

An examination of the available information intimates that there are numerous obstacles and challenges to the implementation of Industry 4.0 technologies in the construction sector. Oke et al. [2023] concentrate on the hurdles that could impede the adoption of robotics and automation systems in developing nations, particularly in Nigeria. They delineate five primary barriers: the fragmented nature of construction processes, opposition from workers and unions, hesitation towards embracing innovations, lack of capacity and expertise, and insufficient backing from senior managers. Pärn et al. [2018] detail the "design clashes" encountered during the construction of an educational building in Birmingham, UK, and how these clashes can escalate project expenses. Wang et al. [2022] identify and evaluate obstacles to digital transformation in the engineering and construction sectors, with the top three being the "absence of industry-specific standards and laws," "lack of distinct vision, strategy, and direction for digital transformation," and "insufficient upper management support for digital transformation."

These barriers and challenges underline the necessity for improved training and education in emerging technologies, superior integration and coordination within construction processes, influential leadership willing to champion innovation, and policies and regulations that stimulate digital transformation within the construction industry. Emerging research opportunities include:

- Understanding and surmounting barriers to implementing robotics and automation systems.
- Resolving design conflicts in the implementation of Building Information Modeling (BIM).
- Overcoming barriers to digital transformation in engineering and construction.
- Studying case studies of success and failure in implementing Industry 4.0 technologies.
- Formulating policies and regulations to facilitate digital transformation in construction.

CONCLUSIONS

There has been a marked increase in the interest in and knowledge of the field of project management and Industry 4.0. An uptrend in research interest in project management and Industry 4.0 has been noted, with a particular emphasis on the application of digital technologies and the assimilation of these principles within the construction industry. Furthermore, this study suggests the existence of an active global research community and diverse topics of interest in this domain.

The systematic literature review illustrates a conspicuous trend in research towards the adaptation and evolution of project management within the context of Industry 4.0. Education and training in new technologies and project management methodologies emerge as pivotal elements to address the changes ushered in by digitalization. The transformation of the project manager's role in response to Industry 4.0 emerges as a recurring theme in the literature. The importance of education, training, and the identification of new skills and competencies to meet the new work paradigm proposed by Industry 4.0 is emphasized. The utilization and adoption of digital technologies in project management is rapidly altering traditional operational methodologies. Studies illustrate how these technologies are being integrated into various industries while concurrently identifying several challenges to their implementation.

Success factors for project management in the era of Industry 4.0 encompass project management maturity, training, and the aptitude to effectively implement Industry 4.0 components. Financial backing emerges as a crucial element for the sustainability of Industry 4.0 initiatives. Digitalization and Industry 4.0 are increasingly impacting project management and sustainability. To adapt to this evolving environment, project management professionals must develop technical and soft skills in addition to adopting new forms of leadership and

collaboration. Lastly, the implementation of Industry 4.0 technologies presents several challenges, including resistance to change, absence of industry-specific standards and laws, and inadequate upper management support for digital transformation.

This review identifies several avenues for future research that could offer enhanced clarity and guidance as organizations and project management professionals navigate the increasing digitization of their sector. Concurrently, these avenues could help identify novel methods for fostering sustainability in project management. Project management in the era of Industry 4.0 is a rapidly progressing field laden with opportunities for new research and innovative practices.

The implications of this study extend to both academia and industry, providing insights that could shape future research directions and practical applications. This study maps the research terrain on the interaction between project management and Industry 4.0, which can be a guiding light for future research endeavors. It identifies critical areas needing further exploration, such as understanding and surmounting barriers to implementing robotics and automation systems, formulating policies and regulations to facilitate digital transformation, and effective strategies for training and education in new technologies. The cross-disciplinary nature of the study also encourages greater collaboration among researchers from fields like project management, engineering, information systems, and sustainability to yield holistic solutions.

The insights drawn from this study offer practical recommendations for the successful integration of Industry 4.0 technologies into project management. The highlighted success factors for project management in the Industry 4.0 era—such as project management maturity, adequate training, and effective implementation of Industry 4.0 components—can act as a guideline for industry practitioners. It underscores the need for robust leadership, a desire to champion innovation, and a shift in work paradigms, emphasizing the development of both technical and soft skills.

This study underscores the critical role of education and training in bridging the gap between current competencies and those required in the digitized industry landscape. This finding should prompt educational institutions and professional training organizations to reassess and restructure their curricula and training programs to meet the evolving needs of Industry 4.0.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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