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Review

Towards a New Paradigm of Project Management: A Bibliometric Review

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Abstract: The advent of the Fourth Industrial Revolution (4IR) has triggered a digital transformation across several industries, including the project management (PM) profession. To achieve competitive advantages, construction industry employers must now utilise technology and data for strategy development, project execution, and delivery. This study reviews the concept of PM through research published on the Elsevier Scopus database from 2010 to date using a sequence of bibliometric analyses. Keywords such as "project management" AND "project management tools" AND "project management techniques" AND "construction industry" AND "built environment" were used for article extraction. VOSviewer, a text-mining tool, was used to analyse the bibliometric connection in PM research within the built environment discipline. Through the sequencing of cluster analysis, the findings revealed that research focus is placed on sustainable development (SD), construction safety (CS), engineering education (EE), project management stakeholders (PMS), risk management (RM), and building information modelling (BIM). More so, the current research focus in PM studies is tending towards knowledge management (KM) and construction innovation (CI). Based on a critical review of extant literature, very few studies have bibliometrically analysed and visualised PM studies. This study sets out to fill this gap by examining the key areas of concentration in published works on the PM concept from 2010 to date. Despite the valuable contribution of this study to the PM body of knowledge, generalisations of the results must be made cautiously due to the use of a single database, which in this case is Elsevier Scopus.

Keywords: construction management; engineering education; fourth industrial revolution; project management; project management education

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1. Introduction

Project management (PM) is as old as humanity. Over the years, several challenging construction projects have achieved completion despite the uncertainties and difficulties that could have rendered them a failure. A large number of these construction projects required advanced planning, an enormous workforce, a considerable amount of time, and precise execution to realise their project objectives. Unfortunately, despite the successful completion of projects despite the limitedness of tools and processes, there is little documentation of the methods and techniques that were deployed in executing these projects. More so, there has been no agreed timeline on when PM came to the fore and different researchers have provided several opinions on its emergence. However, Kwak [1] highlighted four notable periods which underpin its progression. These include prior to 1958, 1958–1979, 1980–1994, and 1995 to present-day. According to Kwak [1], modern PM gained prominence between the 1900s and 1950s (the first era) as the field transformed from a crafting system to human relations administration. This era marked the advent of the Gantt chart and notable projects of this era were the Hoover Dam in Nevada, the Interstate Highway System, and the Manhattan Project, a research and development undertaking during World War II that produced the first nuclear weapons.

The second era (1958–1979) was marked with significant technological advancement and the application of management science. This era marked the arrival of the first plain paper copier (Xerox 914) as well as the commencement of the Program Evaluation Review Technique (PERT) and Critical Path Method (CPM). More so, the era saw the advent of the Work Breakdown Structure (WBS) which was adopted for completing a complex, multi-step project by breaking it down into smaller and more manageable chunks. This era also witnessed the progression of computers from mainframes to minicomputers, which enabled the affordability of computers. Azzopardi [2] reported that this led to the proliferation of numerous PM software tools and companies. The third era (1980–1994) witnessed the multitasking of Personal Computers (PCs) as they impacted various aspects of business and work including PM. The improved efficiency of PCs paved the way for the development of software that was capable of processing complex data that were required to manage projects. Most of these programs were based on the Projects Resource Organization Management Planning Technique II (PROMPT II) model of PM, which was later developed into the Projects in Controlled Environments (PRINCE2) models [1].

With the previous PM eras briefly highlighted, this study examines the future of the PM profession as the Fourth Industrial Revolution (4IR) gathers momentum. This revolution will drive the evolution of the PM profession in the years ahead and the emergence of "Project Management 4.0" (PM 4.0). While several PM studies have surfaced in recent times [3–6], there has been little discussion on the future of the PM profession in the context of the 4IR era. The contributions of this study differ from previous reviews in several ways. Firstly, this study discusses PM in the 4IR dimension and ascertains the impact of 4IR on the project management profession. Secondly, this study adopted a comprehensive bibliometric approach to explore the existing and future research trends in PM research within the built environment context. Findings from this study will provide researchers and industry practitioners with a comprehensive insight into the paradigm shift in the PM profession from an "old" traditional model to a "new" paradigm which is (and will be) heavily disrupted by the technologies accompanying the 4IR era.

2. Literature Review

2.1. Project Management in the Fourth Industrial Revolution Era

The era of the Fourth Industrial Revolution (4IR) is based on the concept of cyber-physical systems (CPSs). These systems allow for various business processes, production processes, and services to be represented in a virtual world through platforms that allow the interaction between humans, machines, goods, and services. According to Bierwolf et al. [7], this era is volatile, uncertain, complex, and ambiguous (VUCA). This new era has triggered a digital transformation across several industries, including the construction sector. To achieve competitive advantages, organisations must now utilise technology and data for strategy development, project execution, and delivery. Technologies such as machine learning, automation, artificial intelligence, the internet of things, data analytics, drone technologies, robotics, and several others have opened new possibilities for the workplace and especially for the smart management of projects. With project managers often at the sharp end of implementing changes, the profession must be flexible and adaptive to this new wave of digitalisation.

Furthermore, large amounts of data will become available and project managers will require superior skill sets to those required in the past to handle these data for project execution [8]. Figure 1 illustrates the evolution of PM from the first era to the present era, which is characterised by the Fourth Industrial Revolution. During the first era, PM was at an empirical stage and was a function of the intuition or experience of project managers rather than the application of scientific methods. The second era of PM relates to the Second Industrial Revolution and was predominantly characterised by the use of Gantt charts in executing projects. The third era was characterised by the emergence of modern methods and techniques for the timely execution of projects such as CPM and PERT. The fourth era of PM (Project Management 4.0) corresponds to the 4IR and is mainly characterised by the projectification of societies, coping with complexities, the transnationalisation of PM, the virtualisation of PM, and the professionalisation of PM [8]. According to Packendorff and Lindgren [9], the projectification of societies refers to the diffusion of PM across various sectors (industry, public, and private) of a society. Several aspects of projectification include the relevance of projects conducted to societal advancement, changes in working styles and the requirements of projects, and acceptance of PM practices in society, amongst others. Coping with complexities will become the norm due to the megatrends of globalisation. It is expected that the 4IR era will ensure the proliferation of standardisation, modularisation, and integrating tools; the augmentation of big data, simulation and statistical analysis tools; an increase in collaborative methods; and increased demand for the adoption of systematic approaches in solving problems [9]. As noted by Gemünden and Schoper [10], transnationalism is a social phenomenon that deals with the growing interconnectivity between individuals, groups, and institutions in a new global space.

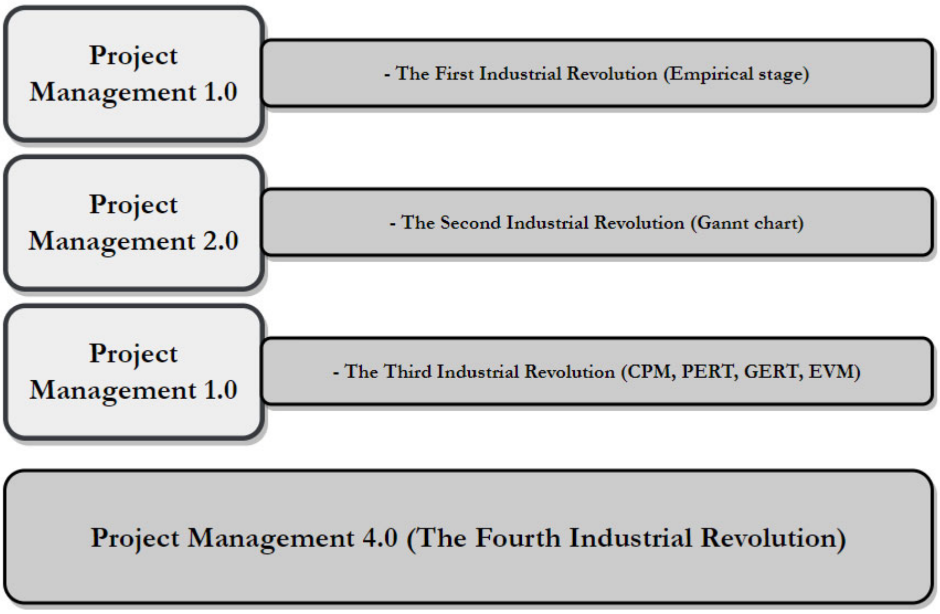

Figure 1. Evolution of PM.

Therefore, the transnationalisation of PM deals with the interaction of individuals, groups, and organisations that are dispersed and culturally diversified on a multinational level. Through PM, the project team can flexibly adopt PM standards to meet the local needs of the organisation. Various technologies and communication tools such as Zoom meetings, Slack, FaceTime, Periscope, video conferences, and chat rooms can now be adopted by virtual project teams when team members are internationally and locally dispersed. The virtualisation of PM indicates the process of managing projects using Information and Communications Technology (ICT) technologies to increase the efficiency, productivity, and scalability of project processes. Some of the features of PM virtualisation include the swift processing of huge amounts of data, seamless communication between members of virtual teams, and the simulation and automation of PM processes. Finally, the professionalisation of PM will be heightened during the 4IR era as the discipline transforms itself into a true profession of the highest competence for the advancement of societal communication. With the numerous technologies accompanying this disruptive era, the cost of training a project manager to be 4IR-savvy and technically competent will be much lower than the cost of keeping an unprofessional PM. Therefore, there will be a high demand for qualified and well-equipped project managers as organisations seek project success to implement their corporate strategies. With 4IR comes new internal and external benchmark standards which would increase the need for professional associations to steer the process of the professionalisation of PM.

2.2. Impact of Industry 4.0 on the Project Management Profession

Based on the various technologies accompanying the Fourth Industrial Revolution (4IR), the PM profession will need to adopt several of the 4IR technologies to execute projects efficiently and effectively to achieve project success. Through data analytics and its abilities, project managers can use analytical reports to break down and uncover complex project data and predict behaviours and outcomes in real time [11]. This predictive information can help project managers to make well-informed decisions based on historical data to keep projects on schedule and within budget [12]. With data analytics, project managers can understand specific patterns and trends which are useful in the formulation of strategic decisions to improve the success of projects, according to Tiwari et al. [11]. Likewise, quality control on projects can be enhanced through machine learning using deep learning techniques [13]. Also, through neural networks, data obtained from drones can be used to crosscheck designs against real-time construction activities to check for design discrepancies [14]. Also, repetitive administrative tasks on site can be automated and streamlined using artificial intelligence (AI), thus allowing project managers to focus on more complex project activities. The application of AI will improve the quality of work, facilitate the timely delivery of tasks, organise the work process, and reduce the cost of labour [15] as machines and man will partner to co-deliver on project scopes and intentions. Furthermore, Gunay et al. [16] posited that through AI, predictive analytics can be utilised based on the specifics of previous projects to ascertain the possible pitfalls and bottlenecks to avoid when embarking on a real-time project or a future one. Therefore, AI will support project managers to become aware of potential risks and budgeting concerns as they venture into new projects.

Furthermore, with the prevalence of prefabrication, modular construction, and additive manufacturing, the use of 3D printing technology will help to reduce fabrication costs and facilitate the timely delivery of projects [17]. Through the use of robotics and automated workflows, the automation of labour-intensive processes will be made possible; this will further provide cost-saving options for project managers and for projects, thus enabling project managers to improve on client satisfaction [18]. Moreover, material cost can be reduced through the automated tracking of construction equipment and materials on site by using embedded sensors as stated [19]. As posited by Wallmyr et al. [20], through the application of simulation technologies like mixed reality (augmented reality and virtual reality) and mobile devices, project managers can give owners a preview of the project before commencement. Therefore, clients can be involved in the construction process for better customisation of the project [20]. Moreover, considering the safety concerns in the construction industry as a result of hazardous work environments, project managers will be able to adopt several 4IR approaches to improve construction safety. Work injuries and accidents on construction sites can be mitigated by virtual safety training [21], utilising risk maps for avoiding work accidents [22], and donning wearable technologies like smart glasses or smart helmets [23]. Simply put, as project managers adopt 4IR technologies, the image of the construction industry will be improved, and the industry will improve its social outlook. Over the years, the construction industry has been well known for its harsh working environment and has been branded as a slow adopter of digitalisation. Therefore, by leveraging the several technologies accompanying this disruptive era, the construction industry will be able to attract talented recruits to their workforce [24]. Furthermore, considering the critical role of PM, it is necessary to be at the fore of innovative changes in the operations of the construction industry in this era.

Moreover, Oesterreich and Teuteberg [25] categorise the relevance of 4IR technologies in the construction industry using 3D value chain models. These include smart factories, simulation and modelling, and digitisation and visualisation. The smart factory chain comprises automation, modularisation (prefabrication), and product life cycles (PLM). The simulation and modelling value chains involve simulation tools, building information modelling (BIM), augmented reality (AR), virtual reality (VR), and mixed reality (MR). Lastly, digitisation and visualisation encompass cloud computing, mobile computing, and social media. According to Oesterreich and Teuteberg [25] and Maskuriy et al. [26], these technologies are necessary for the effective management of construction projects.

3. Research Methodology

The primary goal of this research was to identify prevalent themes and directions in the literature on the topic of PM as it pertains to the field of the built environment. This was accomplished by using a bibliometric strategy to recognise patterns in the literature and draw connections between different areas of expertise and keywords related to project management. The bibliometric method is preferred over a manual literature evaluation in many cases because it allows the researcher to conduct a more thorough and quantitative investigation of the current literature [27]. A four-stage process—data collecting, bibliometric technique application, data analysis and visualisation, and discussion—was used to complete the bibliometric analysis for this research. This research used already published articles found in the Scopus database. Scopus has been more popular as a literature-gathering tool in recent years due to the breadth of the disciplines it covers [27]. Scopus is widely acknowledged as one of the largest abstract and citation databases, including peer-reviewed books, book chapters, journals, and conference proceedings, owing to its extensive coverage and high-quality online sources. Further, Scopus has risen to prominence as a key database for scientific research because of its tendency to provide faster index processing than other significant academic databases like Web of Science (ISI) and Google Scholar. In addition to documenting abstracts and citations of peer-reviewed literature from a wide range of disciplines, the Scopus database also includes intelligence tools for monitoring, analysing, and visualising research. Because insufficiently detailed searches risk missing vitally important documents, much consideration was given to crafting the search statement.

The following retrieval schema were inserted into the Scopus catalogue using the Scopus database: (TITLE-ABS-KEY) (“project management”) AND (“project management tools”) AND (“project management techniques”) AND (“construction industry”) AND (“Built environment”). For bibliometric reviews, keywords directly related to the subject matter are usually recommended. For this study, the keywords chosen best complemented the subject matter discussion. It is key to note that there are hundreds of terms (terminologies) that refer to PM and there was no way to include all. For this study, “project management”, “project management tools”, “project management techniques”, “construction industry”, and “built environment” were directly connected to the subject matter discussed, hence their adoption. The “TI-TLE-ABS-KEY” format was used to indicate the title, abstract, and keywords of a journal or conference publication. The period from 2010 till the present was used for this analysis. In June of 2023, researchers looked through the scholarly literature and found 1174 articles that made use of the aforementioned terms. Journal articles and conference proceedings were excluded from the final cut of the 1174 articles that were retrieved in order to ensure the highest quality. We utilised manual filtering based on these three criteria, and the resulting 328 articles were exported as a CSV file and put through the necessary statistical processing. The extracted articles' metadata, which included article titles, publication dates, authors, author affiliations, abstracts, keywords, volume and page numbers, citation data, reference lists, and Digital Object Identifiers (DOIs), was saved in a CSV file.

The Vos viewer text-mining tool was used to analyse the bibliometric relationships based on the study's findings, providing insight into the PM concept. Among them are (1) surveys of publishing volume focus regions depending on publication year; (2) publication analysis by nation; (3) keyword co-occurrence analysis; and (4) publication-year-specific publication analysis. Vos viewer, according to Van Eck and Waltman [28], is a software tool for creating maps based on network data and is particularly useful for visualising larger bibliometric networks and exploring the maps in a seamless way. A summary of the analysis, techniques, and reasons for using them is shown in Table 1.

Table 1. Bibliometric analysis conducted.

Analysis	Bibliometric Tool	Purposes
Analysis of the number of publications	VOSviewer	To check the rate of publication of PM studies
Analysis of publication per country	VOSviewer	To reveal regions where PM studies have been predominant
Analysis of co-occurrence of keywords	VOSviewer	To examine the main research themes within PM studies
Research focus based on year of publication	VOSviewer	To examine the thematic trends of PM studies

4. Bibliometric Results, Data Analysis, Visualisation, and Discussions

4.1. Publication Per Year

From the 328 extracted articles on the PM subject, 115 were journal articles while 164 came from conference proceedings, as shown in Figure 2.

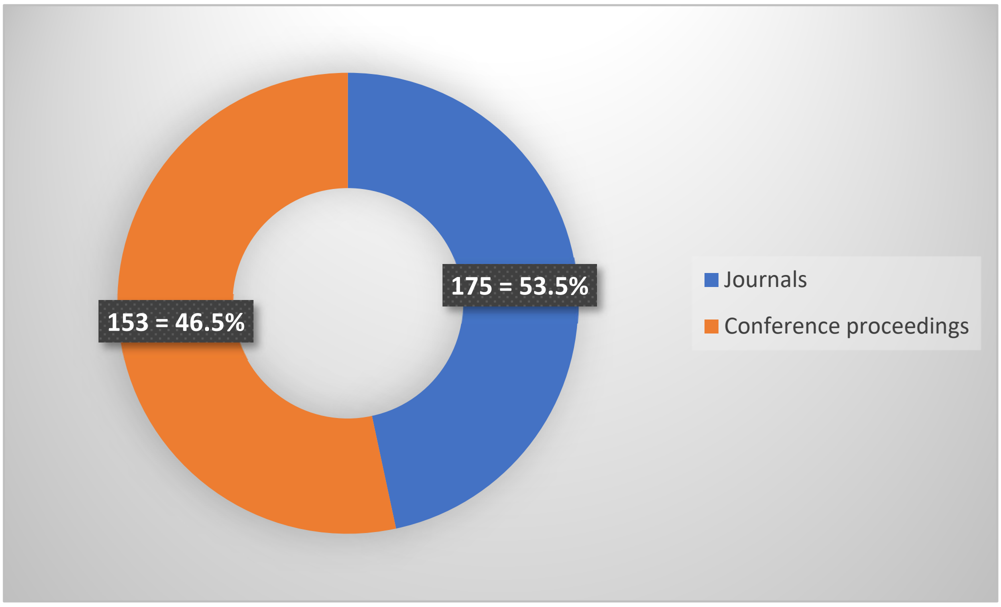

Figure 2. Documents by type.

Figure 3 shows the number of publications on the PM subject from 2010 to date. However, 2010 had the most published PM pieces with 36, while 2023 has seen just 11 items thus far with several months of the year still remaining. Figure 4 also shows a constant rise and fall in the number of publications, which indicates varying interests in the subject matter.

Figure 3. Number of publications per year (2010–2023).

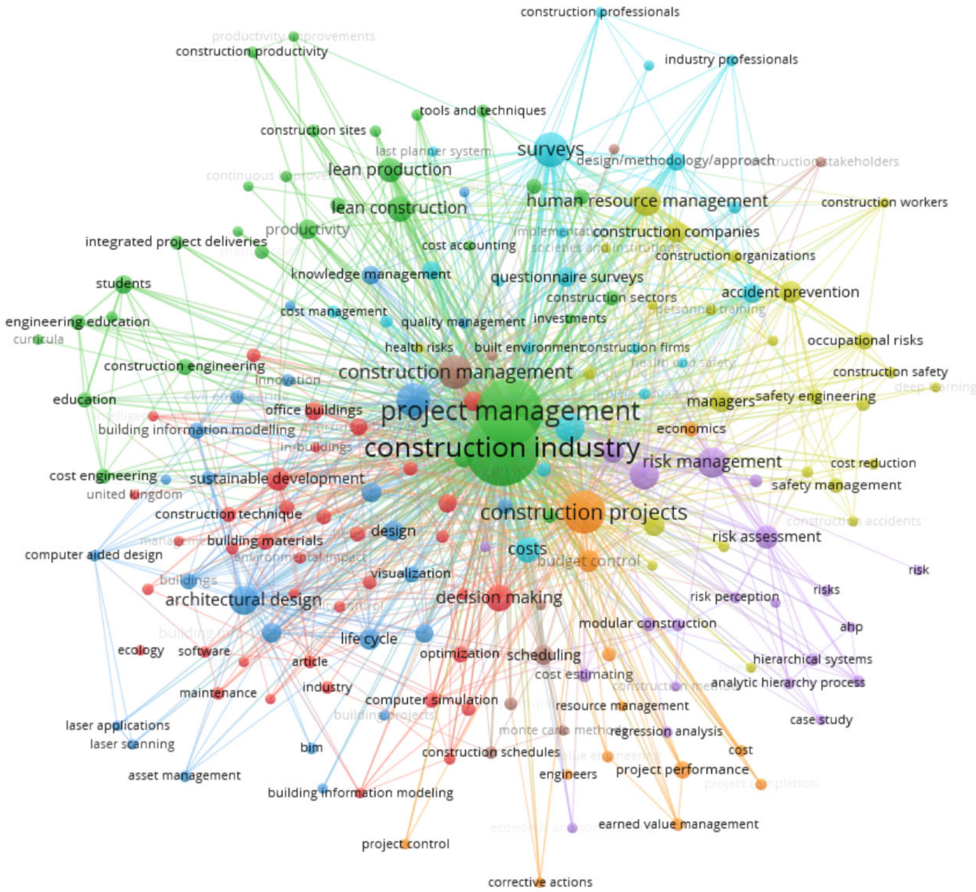

Figure 4. Network visualisation map for co-occurring keywords.

4.2. The Network of Publication per Country

The high number of PM articles necessitates a selection procedure that guarantees no two items with the same nation affiliation will be included in the final database. Table 2 shows that 12 nations meet the criterion because of this group.

Table 2. Number of publications per country.

Country of Publication	Number of Articles	Citations	Total Link Strength
United States of America	73	677	11
United Kingdom	44	127	7
Canada	32	192	5
Australia	23	231	5
China	21	109	4
Malaysia	16	86	1
India	14	66	2
Hong Kong	14	350	4
South Africa	12	79	3
Egypt	11	331	3
Turkey	10	234	1
Taiwan	7	118	1

The United States (73 papers, 677 citations), the United Kingdom (44 articles, 127 citations), Canada (32 articles, 192 citations), Australia (23 articles, 231 citations), and China (21 articles, 109 citations) are the five top nations in PM studies with at least five publications. The large number of cited publications in these nations indicates that research and understanding of PM have progressed. According to Table 2, the United States is the country with the highest number of PM publications published within the time period, suggesting that American researchers are at the forefront of the PM research community at the present time. Overall, these top five countries demonstrate higher levels of research activity for several reasons. Firstly, these countries tend to have well-established research funding mechanisms that support studies in various disciplines, including project management. Also, they boast extensive academic and professional networks and associations that facilitate collaboration, knowledge sharing, and research partnerships among experts in the field. Additionally, the presence of thriving industries closely aligned with project management, such as construction, engineering, and technology sectors, contributes to the demand for research in these countries. Furthermore, these nations have well-developed educational systems offering project management programs, attracting students and researchers who are interested in advancing the field. Moreover, the global influence and recognition of these countries enhance the dissemination and impact of their research in project management. Total link strength, a factor in determining how heavily a characteristic is weighted, was also considered. With a total link strength of 11, the United States was by far the most influential in the PM conversation. Egypt has only contributed 11 papers to the PM literature, yet these works have been cited 331 times, demonstrating their significance.

4.3. Analysis of Co-Occurrence of Keywords

Additionally, a co-occurrence map was developed using the collected bibliographic data to investigate the co-occurrence of terms that have moulded the PM conversation over the last decade. In accordance with the minimal number suggested by Aghimien et al. [27], five keywords were chosen for this analysis. As a result, the minimum number of times a term appears in both the author index and the source index is five. All 328 articles were analysed, and the results showed a total of 3312 keywords; 345 of these terms occurred five times or more. According to Van Eck and Waltman [28], the frequency of a set of keywords increases in proportion to the proximity of those keywords. Figure 4 is a network visualisation showing the 131 most frequent terms and the six groups into which they fall.

Cluster 1—Sustainable Development (SD): This is shown by the red area on the map, which contains 38 terms that often appear together and highlight the overarching topic of sustainable development. Keywords related to social implications, performance evaluation, and incorporating sustainability ideas into PM discussions constitute the basis of this cluster. According to Toljaga-Nikolić et al. [29], the introduction of sustainability concepts into construction processes both at the strategic and operational levels has a significant influence on employees, the community, and the environment itself. For this reason, SD has become a critical idea that concerns society as it helps project managers to focus on issues around value creation, the improvement of performance, increasing efficiency, business agility, project excellence, operational quality, changes in thinking, flexibility, and others [30]. According to the United Nation's World Commission on Environment and Development, SD is defined as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs". This implies that the way our future will be shaped will be heavily dependent on the activities of project managers, as they are tasked with the planning and implementation of relevant projects while also protecting the Earth's resources [31].

This indicates that the sustainability concept is based on the balance of three key dimensions, namely, the economic, social, and environmental [32]. Therefore, the introduction of sustainability revolves around the politics, processes, and procedures of PM, which can be categorised into economic aspects (profit), social aspects (people), and environment aspects (planet) as observed by Toljaga-Nikolić et al. [29]. This has prompted the introduction of sustainability strategies into businesses in a bid to achieve a competitive advantage. For this reason, it is widely predicted that SD will become one of the key aspects of PM in the next decade as it is of crucial importance for the successful implementation of strategies noted by Schoper et al. [33]. It is also worthy to note that sustainable PM is an accelerated roadmap to SD [29]. Therefore, sustainable PM is defined as "the planning, monitoring, and controlling of project delivery and support processes, considering the environmental, economic, and social aspects of the life cycle of a project's resources, processes, deliverables, and effects, to create benefits for stakeholders in a transparent, fair, and ethical way that includes proactive stakeholder participation" [34]. Therefore, it can be concluded that SD revolves around harmonising the economic, environmental, and social interests of projects and acknowledging both the short-term and long-term implications of PM decisions. This underscores the direct correlation between sustainability and PM success.

Cluster 2—Construction Safety (CS): This is shown by the green area on the map, which contains 32 co-occurring terms related to the overarching subject of construction safety. This group of terms is based on search queries related to worker health and safety (H & S) on construction sites. Due to the fact that the construction industry is perceived to have one of the poorest occupational H & S records, the issue of health and safety has become a critical subject across construction industries across the world [35]. For this reason, the issue of H & S has become a well-discussed subject matter within the engineering and research disciplines. According to Zhou et al. [36], construction activities are often carried out under hazardous conditions and clumsy environments and despite the stringent H & S regulations, there has been no significant decline in the number of construction site accidents (injuries and fatalities) as observed by Akinlolu et al. [37]. Some of the main causes of construction site injuries and fatalities include defective equipment, unsafe equipment, faulty scaffolding, excessive noises, dangerous work areas, and electrocution, amongst several others [38].

However, with the advent of the Fourth Industrial Revolution, several novel technologies have been earmarked as a lasting solution to the problems of construction H & S to prevent injuries and accidents on site. Some of these technologies include Geographic Information Systems (GISs), Unmanned Aerial Vehicles (UAVs), building information modelling (BIM), virtual reality (VR), robotics and automation, photogrammetry, sensor-based technologies, and several others [27,39]. According to Li [40], the application of wearable and industrial robots such as robotic arms are practical approaches to improving the H & S of construction site workers. These robotic arms are programmable mechanical arms (consisting of infrared sensors) that possess similar functions to the human arm and can provide real-time feedback on whether objects can be lifted or not.

Similarly, sensor-based technologies have been found to provide real-time construction H & S as they are used for forecasting and environmental monitoring, which could play a pivotal role in the prevention of construction site accidents and lead to the improvement of construction site H & S performance [41]. Also, radio-frequency identification (RFID) technologies have been adopted to demonstrate real-time data gathering as they use electromagnetic fields to identify and track the movement and location of construction site workers, materials, and equipment [42]. These forms of technologies are useful in preventing accidents even before they occur. Furthermore, work injuries and accidents on construction sites can be mitigated by virtual safety training [21], utilising risk maps for avoiding work accidents [22], and donning wearable technologies like smart glasses or smart helmets [23].

Cluster 3—Engineering Education (EE)*:* This is depicted on the map by the blue area, which has 26 co-occurring keywords centred on the fundamental topic of engineering education. This cluster is made up of concepts related to engineering education, which requires providing students in the built environment with the requisite understanding of construction processes and activities throughout their undergraduate education. The whole concept of EE is to equip students with the knowledge and skills required to function effectively in the construction industry after graduation [43]. This is similar to the findings of Russell et al. [44], who stated that EE as a discipline combines coursework and industry experience to ensure students are well rounded as they take up positions in the industry, in both design and supervisory roles, after graduation. By offering undergraduate courses in the engineering discipline, students are adequately prepared for the world of work [43]. Through EE, students gain a valuable understanding of various engineering aspects, such as construction processes, the strength of materials, theory of structures, construction equipment, construction materials, H & S knowledge, geotechnics, and much more.

According to Daoud et al. [45], there are two key parts of EE: technical aspects and managerial aspects. The technical components provide students with the requisite understanding of and expertise for building projects. They teach students the fundamentals of engineering disciplines, construction engineering, construction technology, construction operations, and computer applications in construction. The management components teach students human relations skills, business abilities, and an overall grasp of construction project management. By taking courses in construction management, students are trained in certain PM aspects such as planning, scheduling, cost control, and quality control. As a result of its role in teaching the next generation of construction professionals and project managers, discussions regarding EE have gained steam throughout the years. This has sparked the interest of key players in the EE discussion, including HEIs, educators, parents, researchers, policymakers, the government, and even students, contributing to the ever-growing EE body of knowledge. There has been a proliferation of EE studies discussing concepts such as employability, employability skills, learning tools, learners' assessment, learning theories, pedagogy, pedagogical approaches, skills development, teaching strategies, construction education, project-based learning, knowledge, work experience, work-integrated learning (WIL), and digital literacy and scholastic achievement. It is important to note that quality EE is important in developing the civic, economic, and intellectual aspects of nations. This is because the engineering or built environment students are the leaders, innovators, and construction professionals of tomorrow as they are often known as the solvers of the problems facing humanity.

Cluster 4—Project Management Stakeholders*:* This is illustrated on the map by the yellow area, which has 24 co-occurring terms centred on the fundamental subject of project management stakeholders. This cluster is made up of keywords related to project management stakeholders such as project managers, whose employment will become more dynamic as the Fourth Industrial Revolution approaches. Based on the new wave of digitalisation, the PM profession will need to adopt several of the 4IR technologies to execute projects efficiently and effectively to achieve project success. One of the ways by which the 4IR era can impact the PM profession is in the area of risk management. As noted by Borkovskaya [46], risk management remains one of the most important features of PM.

With the proliferation of huge streams of data available to project managers coupled with data analytics abilities, project managers will be equipped with a deep level of diagnostic and predictive insight that will increase the awareness of risks and thus improve the likelihood of implementing risk-preventive measures to ensure successful project delivery [47]. Moreover, project managers will have access to drone technologies for mapping construction sites, monitoring site activities, and supervision purposes [48]. Data captured by drones can be downloaded into a building information management system (BIM) and used to manage the entire project as noted by Hermann et al. [49]. Chu et al. [50] further suggested that the use of BIM and other simulation technologies can lead to decreased project delivery time and improved projects within the stipulated budget. Drones are also useful in gaining monitoring access to hostile site areas where factors such as height, radiation, wind, and weather can lead to accidents among professionals as stated by Li and Liu [48]. With standard software and analytical tools, data obtained by drones can be used to generate standard reports and track the progress of work on construction sites. In addition, drone technologies will in the future replace the traditional methods that are likely to generate inaccurate data due to factors such as human errors and oversight, as noted by Mosly [51].

Cluster 5—Risk Management (RM): This is shown on the map by the purple area, which has 18 co-occurring terms centred on the fundamental topic of risk management. The concept of risk is a constant feature in the construction industry and risks also occur in various ways. According to Augustine et al. [52], risks can be regarded as any complications or issues that deter the execution of construction projects. As such, risk management (RM) is the process of identifying the various risks that exist in the construction industry and evaluating the procedures to minimise their impact. It also involves the process of planning, monitoring, and controlling the impacts of risks in a construction project [53]. RM also refers to the approaches and activities that are designed to minimise the impacts of risks that may occur during the construction of a project, making it an effective means of detecting and controlling risks as well as increasing the results of positive occurrences within that project. The roles of RM in controlling risks have made it a vital aspect of the construction process as the various measures that are put in place to minimise risks are geared towards achieving the project objectives.

According to Renault and Agumba [54], the RM process covers several important aspects of the identification, assessment, response, and control of project risks. Often known as the first stage in the risk management process (RMP), risk identification involves identifying all potential risks that might occur in any specific construction project. In conducting the risk identification, the project documentation, such as project brief, scope statement, and project management plan, must be in place as it is required in the building of a list of possible risks in that project. The next step of the RMP is risk assessment, which deals with the use of available data to ascertain the frequency of occurrence and the level of consequences in risk management [55]. During this phase, several factors need to be taken into consideration, such as the degree of risk impact on project objectives, the timing of an occurrence, and the likelihood of an occurrence, amongst several others. This information offers a clearer understanding of each risk as well as ways of responding to them. The next step is risk response, which determines the action to be taken to address the risks that were evaluated and assessed [56]. Risk response also entails taking the necessary action to eliminate, mitigate, and combat risks and their consequences throughout the construction of the project. It is a critical stage that takes proper measures to ensure that the project objectives are met. Risk control includes the implementation of the risk plan, which is an integral aspect of the project plan. It also involves the process of minimising risks and increasing the value of the project as it focuses on the way the project objectives are met. According to Renault and Agumba [54], risk control is often regarded as a proactive approach rather than a reactive approach.

***Cluster 6—Building Information Modelling (BIM)**:* This is shown by the turquoise zone on the map, which contains 14 key phrases related to BIM. Architectural design, asset management, built environment, computer-aided design, construction, information management, information theory, quality management, structural design, and visualisation are some keywords that have strong relationships to the core term. Based on these keywords, this cluster comprises BIM-related terms that may aid in the transformation of the built environment and, eventually, the construction sector [54]. Volk et al. [57] define BIM as an intelligent 3D-model-based technique that enables built environment professionals to plan, design, analyse, simulate, construct, and effectively manage buildings and infrastructure. BIM's useful features in information visualisation and efficient collaboration and communication among construction team members have led to its widespread use across a wide range of MDIS [54]. Examples include the fields of computer science (including information and communication technology (ICT) and interoperability), environmental science, material science, energy, and social science (including management and education). The use of BIM results in higher production quality, better design, better scheduling, better customer service, better communications and coordination, improved processes, cost and resource savings, and increased efficiency [58,59].

4.4. Research Focus Based on Year of Publication

As shown in Figure 5, the composite visualisation network map for the co-occurring keywords is presented. In this instance, the various publication years were taken into account. The blue and purple clusters on the map represent the areas of study that were most active between 2012 and 2014; they included sustainability, engineering education, and construction safety. Construction schedules, construction techniques, decision making, energy efficiency, environmental impact, environmental management, construction engineering, construction management, construction process, construction productivity, education, accident prevention, accidents, construction activities, and construction equipment are among the most popular keywords during this time period. In addition, between 2014 and 2016, the focus of research shifted towards risk management in construction activities, such as cost estimation, hierarchical systems, modular construction, regression analysis, risk assessment, risk management, risk perception, and simulation. On the map depicted in Figure 5, these keywords are shown in green. Since 2017, there has been an increased emphasis on building information modelling (BIM), knowledge management, and innovation in construction. The building sector and the built environment are the targets of the yellow term on the map. Achieving project success will necessitate the adoption of multiple 4IR technologies by the project management profession in order to execute projects effectively and efficiently.

For organisations, the impact of this revolution on production processes will not only influence the technological and infrastructural aspects, but also the organisational structures and management styles. With this era of digitalisation, project managers will become the main drivers of projects that are of significant strategic importance for the future of organisations. One of the most remarkable features of the 4IR era is the emergence of hybrid project teams, in which some team members will be virtual assistants (software and applications that possess learning and expressive skills that are similar to humans), while others will be tangible. This new wave of digitalisation will also emphasise the innovativeness of projects and project teams are expected to become smaller and more focused on specific objectives rather than broader ones, as posited by Schwab [60]. Moreover, automation will be the new norm as fringe business processes that do not require analytical and design skills will be gradually automated, which will see corporate structures replaced by more streamlined and seamless structures. Another feature of the 4IR era is that companies will have new business operations models; for instance, a company can be involved in project conceptualisation and implementation across various regions and with the aid of virtual team members from different countries and continents, causing a cultural challenge for project managers [61].

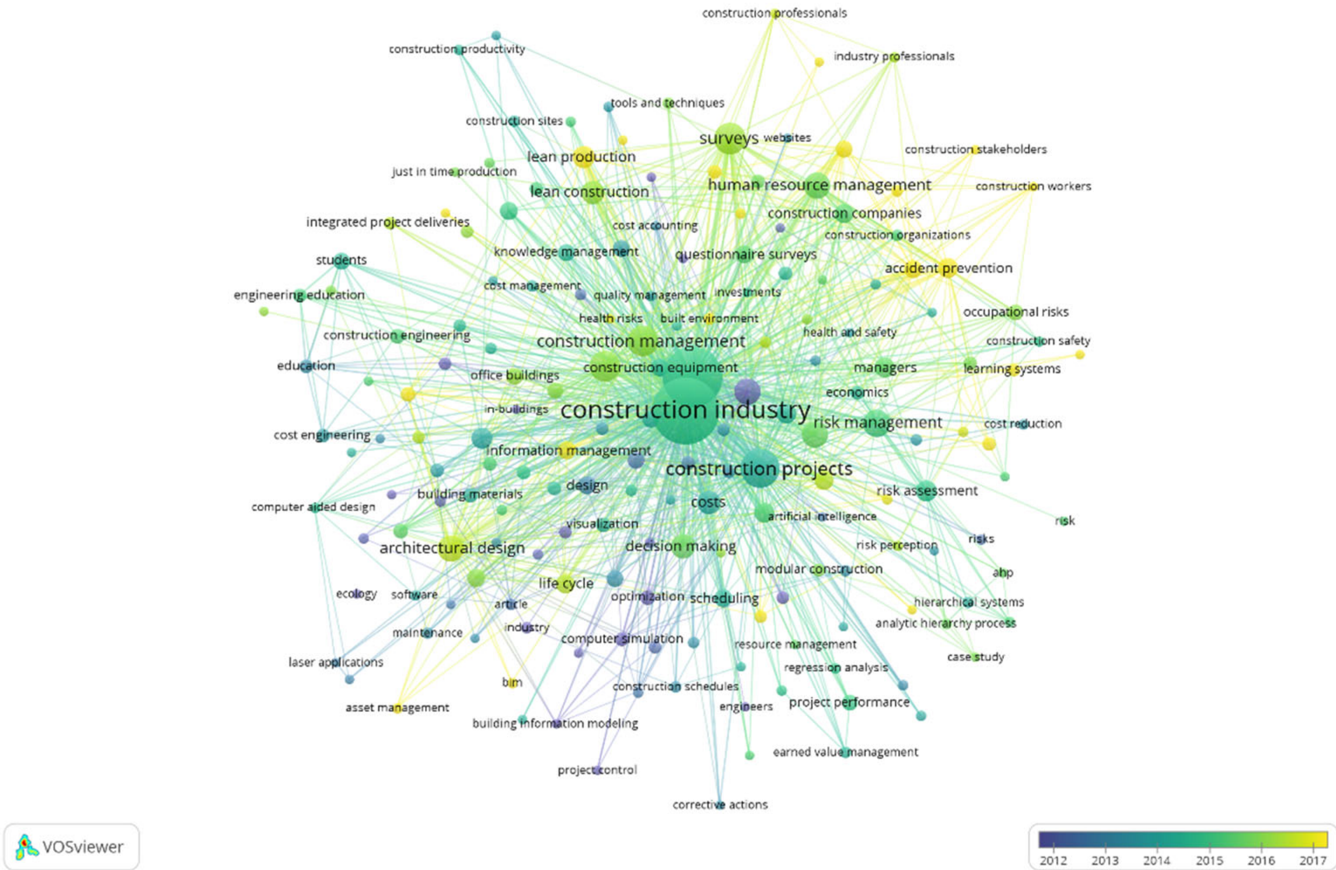

Figure 5. Overlay visualisation map for co-occurring keywords.

Consequently, as the construction industry progressively adopts the technologies of the Fourth Industrial Revolution, the focus of PM research is also affected. To attain competitive advantages, businesses must now employ technology and data for strategy formulation, project execution, and product delivery. Technologies such as machine learning, automation, artificial intelligence, and the Internet of Things have opened new possibilities for the workplace, and especially for the smart management of projects. With project managers often at the sharp end of implementing changes, the profession must be flexible and adaptive to this new wave of digitalisation. Also, with this new wave of digitalisation, project managers are expected to not only possess a deep knowledge of their discipline, but also an in-depth understanding of cyber-physical systems. The advent of the 4IR will further make the construction industry fast-paced, which will require project managers to communicate ideas clearly and effectively to speed up the problem-solving and decision-making process during project execution [62].

5. Conclusions

The main objective of this article was to analyse the evolution of the PM concept over time by examining paradigm shifts within the profession. This analysis was conducted using a bibliometric strategy that involved identifying and mapping key knowledge areas and co-occurring keywords related to PM in the built environment domain from 2010 to the present. The Scopus database was utilised to extract a total of 328 articles, which were further analysed using VOSviewer to investigate patterns and tendencies in PM research. The findings revealed a consistent fluctuation in the number of PM publications between 2010 and the present, with a peak of 36 publications in 2010. Notable countries that emerged as leading contributors to PM article publications included the United States, the United Kingdom, Canada, Australia, and China. The analysis also identified prominent research themes and clusters within the built environment domain, such as sustainable development, construction safety, engineering education, project management stakeholders, risk management, and building information modelling. These findings indicate a shifting focus of contemporary PM studies towards the transformation of the built environment and the construction sector, driven by the Fourth Industrial Revolution (4IR).

The bibliometric study presented in this article contributes to the existing scholarly knowledge by highlighting the research focus areas within PM studies in the built environment. It emphasises the need for the PM profession to adapt to the demands of the 4IR era, where sophisticated and intelligent planning and monitoring tools play a crucial role. Key features of the 4IR era, including the availability of large data, decentralised information, the automation of routine tasks, real-time complex data analysis, and efficient resource management, were also identified. To prepare graduates for the 4IR era, higher education institutions should consider incorporating interdisciplinary and multidisciplinary approaches, promoting lifelong learning, and encouraging the acquisition of new skills through re-skilling, up-skilling, and multi-skilling. Lifelong learning can be facilitated through various means, such as attending conferences, participating in workshops and innovation challenges, and pursuing skills courses and certifications. Additionally, the importance of qualifications obtained from Technical and Vocational Education and Training (TVET) institutions needs to be reassessed in light of the 4IR skills requirements. Strengthening and infusing TVET institutions with 4IR thinking is crucial for producing PM graduates equipped with the necessary skills for Industry 4.0. In response to the 4IR innovations, the construction industry is undergoing a paradigm shift towards a knowledge-oriented approach, supported by the pillars of education, research, and development. This shift may lead to changes in how academic institutions train students, with a reduced emphasis on the highest possible qualification and a greater focus on expertise in 4IR-related technologies. The digitalisation of education, the establishment of technological hubs/labs, and the integration of professional and academic training are potential strategies for adapting to this new paradigm.

The implications of these findings are also significant, especially as the 4IR continues to develop into the Fifth Industrial Revolution (5IR). The increased focus on digitisation, automation, and advanced technologies in the 4IR era has already begun to reshape the PM profession. As planning and monitoring tools become more sophisticated and intelligent, project managers will need to adapt and acquire new skills to navigate the changing landscape. Furthermore, the availability of large data, the decentralisation of information, and real-time complex data analysis present opportunities for more efficient and effective project management. The 4IR advancements in areas such as artificial intelligence, machine learning, and Internet of Things (IoT) offer the potential for enhanced decision making, predictive analytics, and optimization of project outcomes. To fully leverage the potential developments in digitisation and advanced technologies as the 4IR progresses into the 5IR, higher education institutions and training programs must keep pace with the evolving demands of the industry. Interdisciplinary and multidisciplinary approaches will be crucial to equip project managers with the necessary skills and knowledge to harness the benefits of emerging technologies. Lifelong learning will become even more essential, as professionals will need to continuously upgrade their skills and stay abreast of the latest advancements in the field. Additionally, as the boundaries between traditional academic and professional training blur, educational institutions may need to integrate professional and academic training, creating synergies between theoretical knowledge and practical application. The digitalisation of education and the establishment of technological hubs/labs can provide platforms for hands-on learning and experimentation with 4IR technologies.

It is important to acknowledge the limitations of this analysis, which was solely based on the Scopus database. Future research should consider comparing the findings with other databases to obtain a more comprehensive understanding of the PM debate. Such comparisons can contribute to further advancements in this field of study.

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