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A GLOBAL REVIEW OF RISK MANAGEMENT IN THE CONSTRUCTION INDUSTRY: BIBLIOMETRIC ANALYSIS

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Abstract

The purpose of this study is to perform a bibliometric analysis of the literature on risk management in the construction sector. This essay will offer a greater knowledge of how risk management research in the construction sector has evolved over time by using this approach. Even though there have been a lot of empirical studies on risk management in the construction sector, bibliometric studies on the subject are still uncommon. Understanding the growth and evolution of academic research in a given field requires the application of bibliometric analysis. Therefore, a detailed examination of construction risk management and its current state is necessary. The bulk of papers and citations in this topic were examined in this study using scientific mapping and bibliometric performance analysis techniques in order to accomplish the goal. Finding the most productive authors, organizations, countries, and publishing sources was part of this. In addition, a clustering analysis was carried out to map the field's primary research theme throughout the course of ten years. Using the statistical tools Vosviewer and Biblioshiny, the dataset which includes 679 articles that were extracted from the Scopus database between 2014 and 2023 is shown and conclusions are derived. The results of this study have improved our comprehension of risk management in the construction sector, which has significantly added to the corpus of literature and state of knowledge.

Keywords: Risk Management, Construction, Industry, Bibliometric Analysis, Review.

1. INTRODUCTION

In the construction sector, risk management is a crucial component that guarantees the effective completion of projects in the face of unforeseen circumstances and possible dangers. Owing to its complicated nature and wide range of stakeholders, the construction industry is predisposed to a number of risks, from financial uncertainty to safety dangers (Ferede, 2020). As such, the success of projects and the industry's general sustainability depend on the efficient detection, assessment, and mitigation of risks. The dynamic environment in which the construction sector operates is defined by changing market conditions, regulatory constraints, and new technologies. Numerous risks are introduced by these dynamics, and they have the potential to affect project finances, schedules, and, ultimately, deliverable quality. Because of this, those involved in the construction sector need to implement strong risk management techniques in order to foresee and proactively handle any obstacles (Y. Zou et al., 2017).

Reducing the possibility and impact of unfavorable events that could impede project progress is one of the main goals of risk management in the construction industry. This entails taking a methodical approach to recognizing and assessing possible risks, comprehending the ramifications of those risks, and putting in place suitable countermeasures. By doing this,

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construction companies may protect their investments and reputations by strengthening their resistance to outside shocks and uncertainties (Ubani et al., 2015). Furthermore, throughout the project lifetime, transparent and accountable risk management builds stakeholder trust and facilitates more seamless collaboration. It empowers project teams to decide wisely by providing them with a thorough grasp of potential risks and how they could affect project results (Sundararajan et al., 2014). Furthermore, construction businesses can improve resource allocation and reduce costly disruptions by integrating risk management into their project planning and execution processes.

Nevertheless, despite its seeming significance, risk management procedures are frequently dispersed and handled unevenly in the construction sector (Öngel, 2009). This is partially because construction projects are inherently complicated, with many moving parts and relationships that can make risk assessment and mitigation activities more difficult. The sector is decentralized, meaning that several suppliers, subcontractors, and regulatory agencies are engaged, which makes risk management even more difficult. In the construction sector, risks can range from management risks like project delays or changes in the regulatory environment that could impact a project's viability to technical risks like structural failure (P. X. W. Zou et al., 2007). To detect, evaluate, and manage these risks in this setting, scholarly literature on risk management in the construction sector has grown quickly. These studies give experts and practitioners in the construction sector a theoretical and practical basis for putting into practice efficient risk management techniques.

Although there has been a lot of research on risk management in the construction industry (Al-Mhdawi et al., 2023; Ferede, 2020; Ubani et al., 2015; P. X. W. Zou et al., 2007), An overview of research trends, citation patterns, and advancements in popular issues linked to risk management in the construction sector has not been provided by a particular bibliometric review. Previous studies using bibliometrics were conducted by (Gundes & Aydogan, 2016), who talks about the construction sector as a whole. The objective of this study is to map field productivity and assess trends. His research's findings have mapped a number of major research areas in the worldwide construction industry, including risk management, competitiveness, general strategy, and performance measurement. Additional bibliometric analysis was been out by (Zhao, 2023) by conducting an extensive analysis of the literature on construction risk management (CRM) published worldwide between 2000 and 2021, with a focus on determining the themes and philosophical framework of the field. The Web of Science (WoS) core collection database was used to gather the secondary documents. Researchers and practitioners in the industry profit from the study results, which offer a comprehensive grasp of the CRM research.

Our study is different from previous research in this regard in several ways: 1) it focuses on risk management in the construction industry specifically; 2) it uses data from the WoS database for bibliometric analysis; and 3) it employs a more comprehensive analysis that includes performance analysis of the most productive authors, institutional countries, and sources; in addition to performing cluster analysis and science mapping of the most relevant keywords. Additionally, the goal of this study is to expand on the earlier bibliometric

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investigation into risk management in the construction sector. Even though a lot of research has been done on the subject, bibliometric studies on risk management in the construction sector are still uncommon. This work closes the gap left by earlier bibliometric research, making a substantial contribution to the body of knowledge and application of risk management in the construction sector. As a result, the following research questions (RQ) will be attempted to be answered in this study:

RQ1: How well-managed is risk currently in the construction sector, based on the volume of publications?

RQ2: Which authors and organizations are the most productive in terms of publications?

RQ3: According to the volume of publications and the type of cross-collaboration, which productive countries?

RQ4: What are the most relevant terms and sources for risk management studies in the construction sector?

RQ5: Which articles have been cited the most in relation to risk management research in the construction sector?

RQ6: What are the primary fields of inquiry for risk management research in the construction sector?

The purpose of this study is to perform a bibliometric analysis of the literature on risk management in the construction sector. Using this method, the article will highlight research gaps that may need to be filled in the future and offer a deeper knowledge of how risk management research in the construction industry has evolved over time. Scholars, researchers, and practitioners in the construction industry can suggest areas for further research and build more advanced and successful risk management solutions by analyzing trends and patterns in the literature on risk management. Furthermore, policy makers, practitioners, and academics can all benefit from an awareness of recent advances in the literature, which can help them create better laws, promote better risk management practices in the construction sector, and guide future research in this area. This study is divided into six components. Section 1 covers the research backdrop, while Section 2 contains the methodology. The conclusions and debates of this inquiry are then covered in more detail in Section 3. Section 4 contains the study's results and suggestions for additional research.

2. METHODS

The information for this analysis was gathered using the bibliometric approach. As stated by (Kumar, 2016), the bibliometric technique is a helpful strategy for tracking and summarizing the statistical knowledge of a specific term or idea published in a particular domain. A researcher can record and analyze a source of metadata and knowledge spread using bibliometric analysis. Faithorne created the term "bibliometrics" in December 1969 to characterize the statistics of articles produced in a certain area, including but not limited to: concepts, studies, trends, methodology, keywords, and reference sources (Broadus, 1987).

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Because bibliometric analysis provides science mapping on the pertinent publication database, it is widely used in literature reviews to help academics gain a deeper understanding of the topic. By doing a bibliometric review, the researcher can more successfully integrate their findings into the body of existing knowledge (Abdul Rahman et al., 2022).

2.1. Data Source

Using Scopus, a bibliographic analysis of publications released as of January 10, 2024 in the construction industry and risk management fields was carried out. Scopus was employed for this study since it is the largest collection of citations and abstracts from scholarly publications in the fields of business, management, and accounting (Fahimnia et al., 2015). About 20,000 scholarly journals are included in Scopus, along with 24,000 extra titles, 360 new magazines, 750 book series, 195,000 additional volumes, and 60 million records. A database of big might offer a comprehensive summary of all research conducted worldwide. The scientific community as a whole agrees that Scopus is a very useful resource for finding important information. Additionally, the emphasis on the Scopus database was made by (Chicksand et al., 2012) as an excellent source for compiling publications that have undergone peer review.

2.2. Search Strategy

To describe the distribution patterns of research publications within particular topics and time periods, this study combined bibliometric analysis with quantitative and statistical analysis (Napitupulu & Yakub, 2021). Using keywords, we begin the data collecting process by looking for relevant literature on our research topic. A keyword is a specific kind of search string that is used to find datasets related to the topic of public sector adoption of cloud computing. It consists of a well-developed term or phrase. Thus, the combination of keywords used to run a query in the Scopus database is (1) risk management and (2) construction. The following complete keywords were looked up using the article's title, keyword, and abstract as a guide:

(TITLE-ABS-KEY (“risk management”) AND TITLE-ABS-KEY (construction))

By limiting our search to journal articles (IC2) and the English language (IC1), we were able to narrow down the scope of our investigation. This is due to the fact that journal articles—as opposed to other formats like conference papers, monographs, book chapters, etc.—go through a more thorough process of scientific peer review. They were our first choice above other formats (Tas & Bolat, 2022). Beyond national boundaries, English has also become a language that is widely spoken and understood. Moreover, we lack the resources necessary to translate texts from other languages—such as Spanish, Russian, etc.—into English. To get more pertinent data, we additionally filter the data depending on particular business, management, and accounting subjects. Thus, a total of 679 metadata sets were retrieved from the Scopus database as of January 10, 2023. Once the screening process is complete, we make sure the dataset is free of duplicates. Consequently, a total of 679 data points were collected for additional examination. Figure 1 shows the exact procedures for the bibliometric analysis and search approach used in this study.

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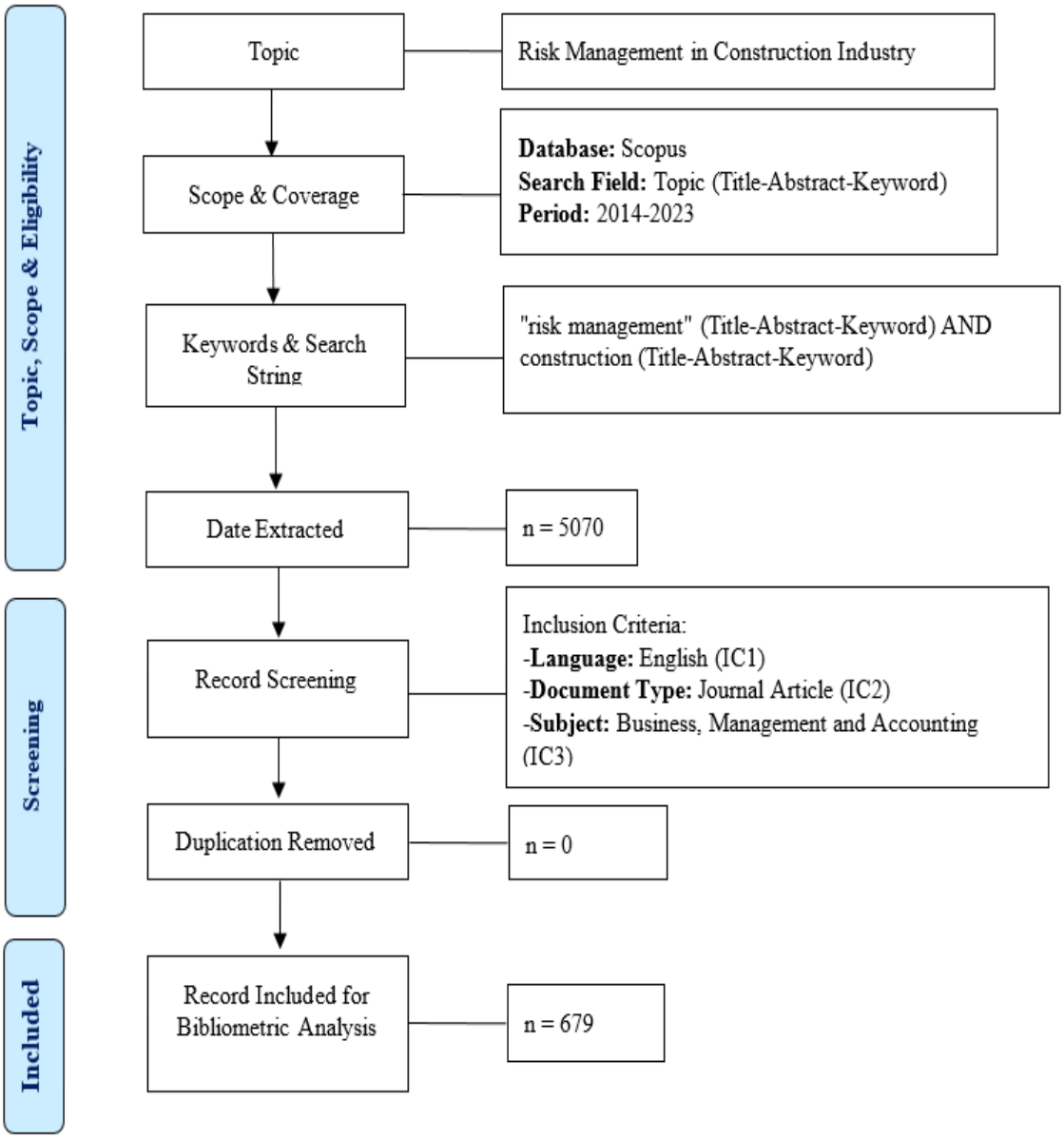

Figure 1: Flow diagram of the search strategy (Zakaria et al., 2021)

2.3. Data Analysis

According to, there are two main methods for thorough bibliometric analysis (Donthu et al., 2021): The first two are performance analysis and science mapping. Science mapping focuses on the connections between research parts, whereas performance analysis focusses on the contributions of research components in a specific subject. According to this viewpoint, research consists of authors, institutions, publications, countries, and affiliations. Citations represent impact and influence, whereas publications act as a proxy for output. The scientific

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mapping encompasses the intellectual exchanges and structural links among research aspects. Citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis methodologies are all used in science mapping. These methods are useful for illustrating the bibliometric and intellectual structure of a study topic when paired with network analysis. In this investigation, we used co-occurrence analysis to forecast future research in the subject and identify the main study topic based on theme clusters. Co-occurrence analysis is also useful for showing how a field has changed over time. It's a useful tool for pinpointing hotspots in a variety of industries (Tas & Bolat, 2022). The bibliometric analysis in this study made use of Vosviewer and Biblioshiny. Vosviewer is a complex tool for organizing and displaying bibliometric networks that was developed at Leiden University in the Netherlands. It also provides text mining tools that facilitate the construction and visualization of crucial label co-occurrence networks extracted from a vast array of scientific publications (van Eck & Waltman, 2010). Since Biblioshiny allows users to conduct pertinent bibliometric and visual analyses on research constituent performance, it was used.

3. RESULT AND DISCUSSION

3.1. RQ1: How well-managed is risk currently in the construction sector, based on the volume of publications?

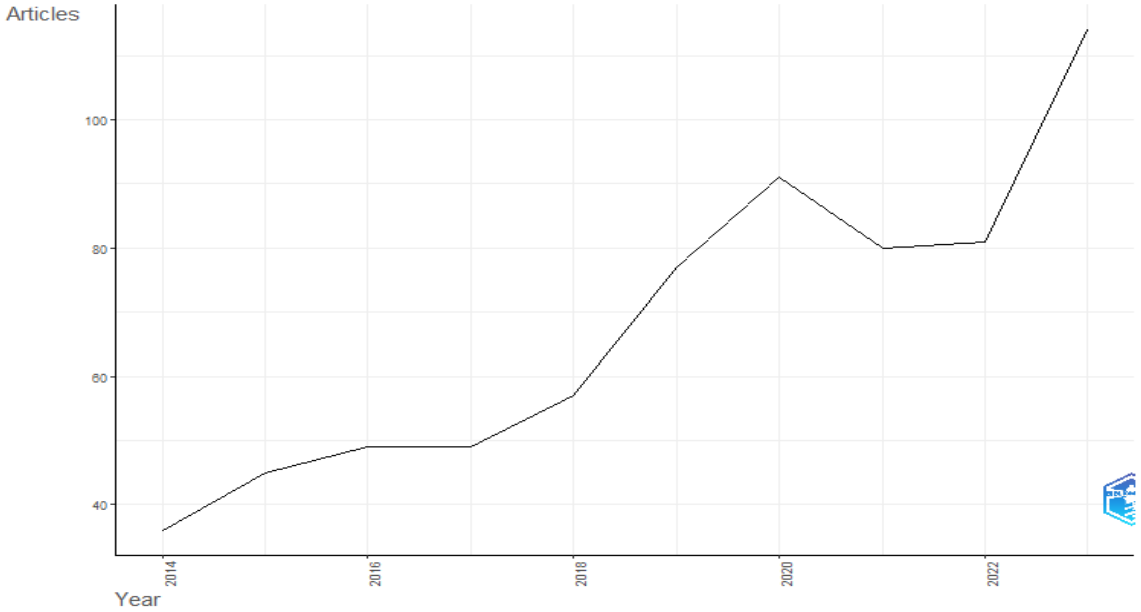

Figure 1: Publishing Tren in the area of risk management in construction industry

Figure 1 displays the years that the relevant publications and citations were obtained. It also displays the trend of the quantity of articles generated over time. We can follow the development of research on the usage of cloud computing in the public sector based on the amount of papers. We can also ascertain whether there is an upward or downward trend in this field based on the volume of publications that the research yielded. The general research trend

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for this theme has clearly increased during the last ten years (2014–2023). This indicates the keen interest that academics have in learning more about the application of risk management in the construction sector or how businesses can use it to manage and control risk and enhance overall performance. There are two distinct periods in the publication trend. There was very little increase in the number of publications between 2014 and 2018, with roughly 36 documents published in 2014 and 57 in 2018. There was a notable rise in publications from 2019 to 2023, with 77 documents in 2019 and 114 documents in 2023. This indicates that the Covid-19 epidemic has had a significant effect on the construction sector. The COVID-19 pandemic has made the construction industry face further difficulties. Significant productivity losses, rising material costs, payment delays, supply chain distribution, contractual, legal, and insurance implications, unavailability of necessary supplies, tools, and equipment, difficulties gaining access to the workplace, implications for health and safety, a shortage of labor resources, labor restrictions, and psychological difficulties brought on by job loss and the absence of a social security system are a few examples of these risks (Al-Mhdawi et al., 2023). This has encouraged research on the topic of managing risk management in construction companies to grow significantly.

3.2. RQ2: Which authors and organizations are the most productive in terms of publications?

You may identify the most well-known authors and organizations on the subject of risk management in the construction industry by looking at the number of documents that each author and company generates. By using this strategy, the researchers will be appropriately guided in an effective manner. Using Biblioshiny as a tool, the researchers created a comprehensive list of the top ten authors and countries in this field. The aforementioned work was finished using collaborative authorship analysis and bibliographic data files. Figure 2 displays the investigation's findings. The results indicated that a select group of authors and an organization had produced important works that attested to their significant contributions to the field. This revelation opens up a brand-new area of research.

Research regarding the application of cloud computing in government is being worked on by 1745 authors. Together, these authors have produced 679 research studies over the last ten years. Figure 2 contains a detailed list of the authors who have published extensively on this topic. It is evident from the publication of multiple publications that several authors have contributed significantly to this field. Among them, Zhao, X is the most prolific author. Zhao, X has established a notable reputation for himself in the subject of risk management in the construction sector, having published 16 times. With ten documents published, Hwang, B-G, Gunduz, M, and Wang, Y trail him with nine articles each. Chileshe, N, Deng, X and Low SP contributed 8 publications, Li, Z with 7 documents while Li, X and Wang, X have 6 articles.

Out of all 598 institutions, Table 1 also identifies the top 10 organizations that have contributed most to the study of risk management in the construction sector. With 49 publications, Notreported has established itself as one of the top organizations for risk management in the construction sector. The second well-known organization to release 26 documents was Hongkong Polytechnic University. With 25 articles in third and fourth position, respectively,

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are Southeast University and University of South Australia. The rest of them are Tsinghua University (23), Islamic Azad University (22), University of Tehran (18), Qatar University (16) while Chongqing University and Ho Chi Minh City Open University have 15 documents published.

Table 1: The most relevant authors and organizations based on number of publications

No	Author	Document	No	Author	Document
1	Zhao, X	16	6	Deng, X	8
2	Hwang, B-G	10	7	Low, SP	8
3	Gunduz, M	9	8	Li, Z	7
4	Wang, Y	9	9	Li, X	6
5	Chileshe, N	8	10	Wang, X	6
No	**Organization**	**Document**	**No**	**Organization**	**Document**
1	Notreported	49	6	Islamic Azad University	22
2	The Hong Kong Polytechnic University	26	7	University of Tehran	18
3	Southeast University	25	8	Qatar University	16
4	University of South Australia	25	9	Chongqing University	15
5	Tsinghua University	23	10	Ho Chi Minh City Open University	15

3.3. RQ3: According to the volume of publications and the type of cross-collaboration, which productive countries?

Our research indicates that 60 countries have expressed interest in learning more about risk management in construction industry. Table 2 displays the top ten countries that we determined have made the greatest contributions to this field of study. China emerged as the most prolific country, producing 91 published documents, or 13,40% of all documents, when compared to other countries. USA came in second with 61 documents, followed in third place by the Australia with 48 published documents, whereas United Kingdom (39), Iran (28), India (27), Malaysia (22) and Hongkong (14). Canada and Turkey have 13 documents published. Thus, China leads the world in the research of risk management in the construction industry based on productivity. These findings can serve as a guide for scholars and industry professionals investigating the possibilities of construction industry implement the risk management.

Furthermore, among the top ten countries, a few have a large number of articles published in multiple country publications (MCPs), which are publications done in conjunction with other countries. The top five countries with the greatest number of international articles publishing collaborations above ten documents are China (37), Australia (31), USA (20), United Kingdom (20), and Iran (10). This indicates that scientists from these countries frequently work together to conduct research on the implementation of risk management in the construction industry. In the other hand, Hongkong (7), India (2), Malaysia (2), Canada (2) and Turkey (1) have less than 10 documents collaboration. Besides, there are five countries with the highest number of single country publications (SCPs), or works published independently or without cooperation above 20 publications. They are China (54), USA (41), India (25), United Kingdom (24) and Malaysia (20). This implies that the majority of the research from these countries may be

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carried out inside their own borders. Therefore, it can be inferred that China leads the world in both productivity and international cooperation when it comes to risk management in construction industry research.

Table 2: The most relevant countries based on documents and collaboration

No	Country	Document	%	SCP	MCP
1	China	91	13,40	54	37
2	USA	61	8,98	41	20
3	Australia	48	7,07	17	31
4	United Kingdom	39	5,74	24	15
5	Iran	28	4,12	18	10
6	India	27	3,97	25	2
7	Malaysia	22	3,24	20	2
8	Hong Kong	14	2,06	7	7
9	Canada	13	1,91	11	2
10	Turkey	13	1,91	12	1

3.4. RQ4: What are the most relevant terms and sources for risk management studies in the construction sector?

With the identification of terms (keywords) and sources that are extremely pertinent to the topic of risk management in construction industry, this study seeks to improve the resources available to scholars and practitioners. This implies that the goal of the study is to offer a well selected list of terms and references that can facilitate additional research in the area. Researchers and practitioners can learn a great deal about current trends and significant concerns in the field by looking at keywords that appear often. Research articles' themes and primary focus are frequently reflected in their keywords. A graphic depiction of the keywords found in this study and their frequency of recurrence is shown in Figure 2. The terms that are used the most frequently in this study literature are highlighted. The most pertinent keywords for this study are risk management (286 occurrences), project management (67), construction (61), risk (45), construction projects (40), risk assessment (39), construction industry (30), portfolio construction (25), construction management (24) and risk factors (18). These keywords are commonly studied and probably reflect significant questions about what domains or aspects to take into account that affect the risk management adoption in the construction domain as well as what models can be used to risk management implementations.

The main discussion revolves around risk management within construction projects, evident from the substantial occurrence of "risk management" and "risk". This discussion likely encompasses identifying, assessing, mitigating, and monitoring risks throughout the project lifecycle. Complementing this focus is a discussion on “project management”, indicating considerations for scheduling, budgeting, resource allocation, and overall project coordination within the construction context. The presence of terms such as "risk assessment" and "risk factors" underscores the importance of evaluating and understanding various factors contributing to risks within construction projects. Additionally, the keywords "construction industry" and "construction management" suggest broader discussions on industry-specific challenges, best practices, and regulations. The mention of "portfolio construction" hints at

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discussions regarding managing portfolios of construction projects, including strategies for diversification, resource optimization, and risk allocation. This material essentially highlights how crucial it is to pinpoint pertinent keywords in order to help practitioners and scholars alike comprehend key themes, research trends, and new problems pertaining to the use of risk management in construction industry.

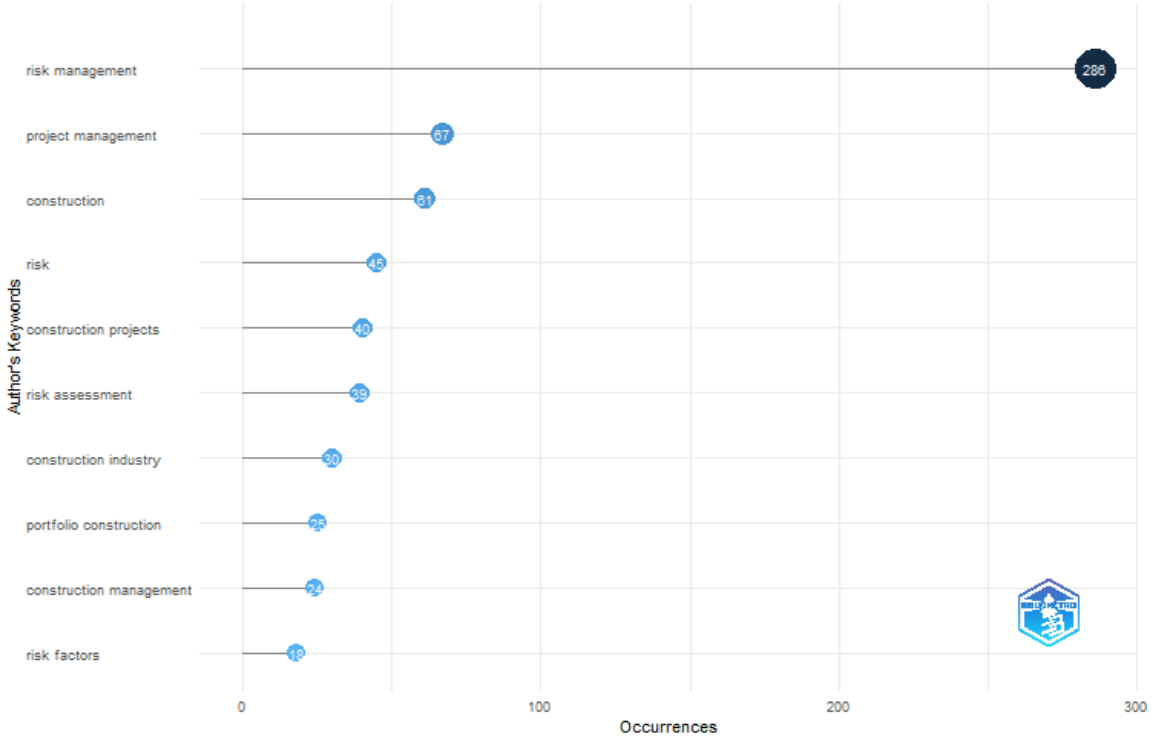

Figure 2: The most relevant terms based on occurrence

Finding reliable sources is just one of the many reasons it's crucial to examine the most popular sources on a subject. Scholars can determine reliable and authoritative sources on a subject by looking at the most often cited sources. This makes it easier for scholars to locate trustworthy references for their work or arguments. Getting the most recent information is another advantage. Regularly consulted sources could show new developments or trends in the field. Researchers can better grasp the most recent advancements and discoveries in this discipline by using this study.

The top ten specialized publications that have significantly contributed to the publication of papers in this particular field of research are shown by an examination of the sources used to publish research on cloud computing adoption in public sectors: With 94 papers (13,84%) Engineering, Construction and Architectural Management is the most prominent publication source, followed by Journal of Construction Engineering and Management with 80 documents in the second place. Several other research journals were also identified by the analysis as some of the more frequently used sources for risk management research in the construction industry:

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International Journal of Construction Management (46), Journal of Management In Engineering (41), Journal of Civil Engineering and Management (23), Journal of Cleaner Production (23), Journal of Portfolio Management (23), Construction Management and Economics (15), International Journal of Project Management (15) and IEEE Transactions on Engineering Management (9). A total of 175 different sources were employed for the publication of 679 research articles, according to additional study on the number of outlets for research publication. This shows a very diversified number of sources of publication, as shown in Table 3 as follows:

Table 3: The Most Relevant Sources of Publication

Sources of Publication	Document	%
Engineering, Construction and Architectural Management	94	13,84
Journal of Construction Engineering and Management	80	11,78
International Journal of Construction Management	46	6,77
Journal of Management In Engineering	41	6.04
Journal of Civil Engineering and Management	23	3,38
Journal of Cleaner Production	23	3,38
Journal of Portfolio Management	23	3,38
Construction Management and Economics	15	2,21
International Journal of Project Management	15	2,21
IEEE Transactions on Engineering Management	9	1,32

3.5. RQ5: Which articles have been cited the most in relation to risk management research in the construction sector?

Knowing which papers are most frequently cited in a given topic is very important and has many advantages. These texts, which are frequently recognized for their influence, represent significant turning points in the field of scholarship. Examining these widely cited books provides insights into the significant contributions that have influenced the discourse in a certain field. Finding these often-referenced papers not only indicates that the academic community recognizes them, but it also helps to stay up to date on the most recent advancements. These kinds of publications usually capture the latest developments and trends, enabling scholars and enthusiasts to follow the changing field they are interested in.

The top ten most cited papers on the topic of cloud computing adoption in public sector research are displayed in Table 4. With 325 total citations and a TC per year of 54,17, the article by (Darko et al., 2019), which was published by Taylor & Francis, is the most influential work in this field. This paper reviews 77 AHP-based papers published in eight selected peer-reviewed Construction Management (CM) journals from 2004 to 2014 to better define and delineate analytic hierarchy process (AHP) application areas and decision-making problems solved within CM. The findings indicated that risk management and sustainable construction were the most popular AHP application areas in Construction Management (CM) domain. In addition, this study provides a useful reference for researchers and practitioners interested in the application of AHP in CM.

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The second most cited document is the paper work of (Qazi et al., 2016) has 23 TC annually and 207 total citations. This paper titled “Project Complexity and Risk Management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects” published by Elsevier. Project complexity has been extensively explored in the literature because of its contribution towards the failure of major projects in terms of cost and time overruns. This study proposed a new process that aids capturing interdependency between project complexity, complexity induced risks and project objectives. The proposed modelling approach is grounded in the theoretical framework of Expected Utility Theory and Bayesian Belief Networks. Moreover, this paper considered the decision problem of identifying critical risks and selecting optimal risk mitigation strategies at the commencement stage of a project, taking into account the utility function of the decision maker with regard to the importance of project objectives and holistic interaction between project complexity and risk.

Table 4: The Most Cited Documents

Document	DOI	Total Citations	TC per Year
Darko A, 2019, Int J Constr Manage	10.1080/15623599.2018.1452098	325	54,17
Qazi A, 2016, Int J Proj Manage	10.1016/j.ijproman.2016.05.008	207	23,00
Zhao X, 2016, J Clean Prod	10.1016/j.jclepro.2015.11.042	197	21,89
Li Cz, 2017, J Clean Prod	10.1016/j.jclepro.2017.07.156	180	22,50
Hwang B-G, 2014, Int J Proj Manage	10.1016/j.ijproman.2013.01.007	156	14,18
El-Sayegh Sm, 2015, J Manage Eng	10.1061/(ASCE)ME.1943-5479.0000365	141	14,10
Xia N, 2018, Int J Proj Manage	10.1016/j.ijproman.2018.03.006	127	18,14
Gondia A, 2020, J Constr Eng Manage	10.1061/(ASCE)CO.1943-7862.0001736	126	25,20
Tixier Aj-P, 2014, J Constr Eng Manage	10.1061/(ASCE)CO.1943-7862.0000894	115	10,45
Liu Z-Z, 2016, Int J Proj Manage	10.1016/j.ijproman.2015.11.003	112	12,44

Understanding the most cited documents is important because it can be used as a compass to help people navigate the complexities of academic discourse, improve their comprehension of the past and present, and enable them to make meaningful contributions to the ongoing intellectual narrative in their field of interest.

3.6. RQ6: What are the primary fields of inquiry for risk management research in the construction sector?

According to Si et al. (2019), keywords are terms that succinctly summarize the approach, core idea, and content of scientific publications. The co-occurrence analysis methodology was developed by an analysis of author keywords. A threshold of five occurrences was established. 66 keywords with a minimum of five occurrences of each term were successfully obtained from the original pool of 1943 keywords.

Though they are worded differently, many keywords have similar meanings, thus it is necessary to clean some of them up first. Commonly used terms in scholarly literature include "construction project" and “construction projects" are the same meaning keyword. In addition, the terms "construction" and "contracting" are needed to be combined. Beside the several keyword that have same essentials, there are some trivial keywords like case study, monte carlo

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simulation, pls-sem, quantitative methods, questionnaire survey, simulation and structural equation modelling. These keywords are deleted because it is not related to the topic of this study. For this reason, we conduct data cleaning process by using Vosviewer's thesaurus in order to combine and delete the previously specified keywords. Finally, a total of 57 keywords have been chosen for more examination. More often occurring keywords may be interpreted as indicating that the study's topic is well-liked.

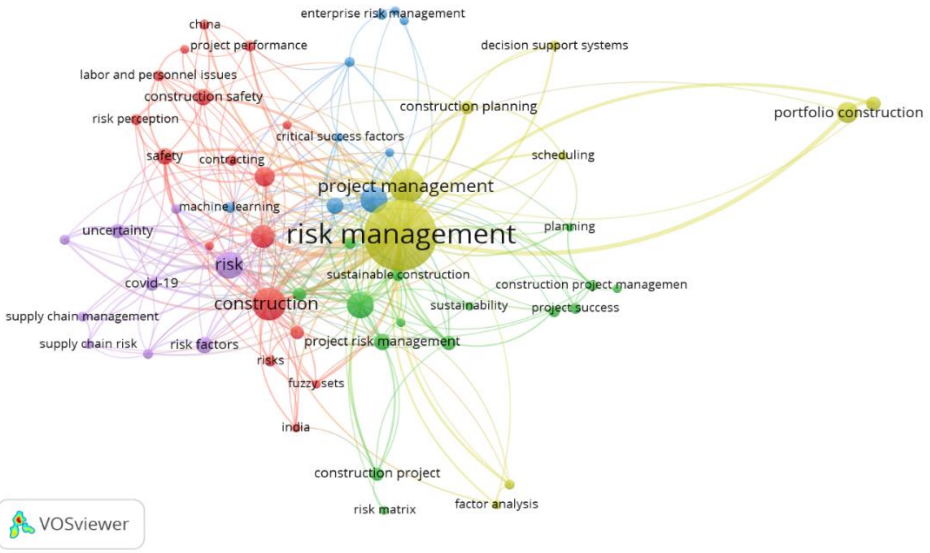

Figure 3: Network Visualization based on Author Keywords

A network visualization, or visual depiction of co-occurrence based on author keywords in the analysis, is shown in Figure 3. The co-occurrence network in Vosviewer depicts the primary line of inquiry for risk management research in the construction industry. It can be deduced from the mapping data analysis that the risk management research in the construction industry is associated with five main clusters. The five clusters found in the analysis of keyword co-occurrence are described in detail in the following paragraphs:

- Cluster 1 (red) consist of 17 keywords in total. The theme of this cluster is labelled as "Construction project safety and workforce management". This cluster's keywords are construction management, labor and personal issues and safety risk management. This theme discusses the key areas related to construction management, addressing both the management of construction projects and the management of workforce-related issues, including labour and personal matters, while also emphasizing safety risk management within the construction context (Durdyev & Mbachu, 2011).
- Cluster 2 (green) consist of 15 keywords in total. The theme label is “Integrated risk management in sustainable construction practices". The important keywords in this cluster are risk assessment, risk analysis and sustainable construction. This theme encapsulates the essential elements of evaluating risks, analyzing them comprehensively, and implementing

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sustainable practices within the construction industry. By integrating risk assessment and analysis methodologies into sustainable construction approaches, projects can strive for enhanced resilience, efficiency, and environmental responsibility (Settembre-Blundo et al., 2021).

- Cluster 3 (blue) has 9 keywords in total. Enterprise risk management, critical success factors and knowledge management are the essential words. "Integrated Business Sustainability and Innovation" is the label assigned to this cluster. This theme highlights the strategic approach of managing risks at the enterprise level, identifying critical success factors crucial for achieving organizational objectives, and leveraging knowledge management practices to foster innovation and sustainable growth. In today's dynamic business environment, organizations need to integrate risk management, success factors identification, and knowledge utilization to thrive and adapt effectively (Egbu, 2004). This theme underscores the interconnectedness of these elements in driving organizational resilience, competitiveness, and long-term success.
- Cluster 4 (yellow) has 9 keywords and is labelled as "Strategic portfolio optimization and project execution". Portfolio construction, performance measurement and project management are the primary keywords. This theme encompasses the strategic aspect of constructing portfolios, the need for precise performance measurement to gauge effectiveness, and efficient project management to ensure successful execution. It highlights the importance of strategic decision-making, performance evaluation, and effective management practices in achieving project objectives within a portfolio context (Demirkesen & Ozorhon, 2017).
- Cluster 5 (purple) with 9 keywords is labelled as "The challenges faced by construction industries during the Covid-19 pandemic". Covid-19, uncertainty and supply chain risk are the three essential keywords. This theme explores how the pandemic has introduced unprecedented levels of uncertainty and risk into supply chains worldwide in the construction firms (Magableh, 2021). It may delve into the disruptions caused by lockdowns, travel restrictions, and shifts in consumer behaviour, highlighting the need for agile supply chain management strategies to mitigate risks and ensure continuity of operations. The theme also discusses the importance of resilience, flexibility, and innovation in navigating through uncertain times, as well as the lessons learned and potential long-term impacts on supply chain management practices.

4. CONCLUSION

The purpose of this research is to examine the patterns and advancements that may contribute to our comprehension of the adoption of cloud computing, particularly in the public sector. A bibliometric study on risk management in the construction industry is still rare, despite the fact that many empirical studies have been done on the topic. The findings of this study have expanded our knowledge and understanding about research trend of risk management especially in the construction industry, which has made a substantial contribution to the body of literature and current knowledge. Additionally, the research gaps identified in earlier

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bibliometric research have been filled by this study. This study not only offers a full picture of current trends and advancements through a thorough examination of existing scientific literature, but it also identifies the shortcomings of earlier research. In this study, we analyzed various important facets of the intellectual landscape of academic research on risk management in the construction industry using Vosviewer and Biblioshiny as statistics and visualization tools. Based on authorship, institutional collaboration, countries, and keywords, the result highlights major research themes and topics that significantly influence the intellectual landscape. The purpose of the citation analysis was to track the progression of ideas within a subject, identify key works, and assess the impact of research. It is thus hoped that the findings of this study will be able to offer more in-depth and pertinent insights for construction practitioners, as well as act as a useful reference for scholars who wish to delve deeper into the intricate dynamics of risk management research in future construction industry settings. The ongoing research is expanding on the bibliometric analysis that has been conducted with a more focused review, for example by conducting systematic literature review or other reviews.

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