Barriers to Adoption of BIM-Based Risk Management in the Construction Industry: A Systematic Literature Review and Bibliometric Analysis

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BARRIERS TO ADOPTION OF BIM-BASED RISK MANAGEMENT IN THE CONSTRUCTION INDUSTRY: A SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

Abdulhaqq ABDULWAHAB
Rasheed Babatunde ISA
Abdulkabir Opeyemi BELLO
Department of Building, Federal University of Technology, Minna, Nigeria

ABSTRACT

The integration of Building Information Modelling (BIM) technology has the potential to revolutionise risk management practices in the construction industry. However, despite its numerous benefits, adopting BIM-based risk management faces significant barriers that hinder its widespread implementation. In order to gain insights into the BIM-Based risk barriers, this study conducts a systematic literature review and bibliometric analysis to explore the current state of research in the domain. The study utilises a comprehensive search strategy to identify relevant publications from SCOPUS databases. A rigorous screening process is employed to select scholarly articles examining the barriers to adopting BIM-based risk management in the construction industry. The study adopts the "barriers to adoption of BIM-based risk management in the construction industry" as a search command. A total of 2070 articles were identified from the initial search, and 22 were considered in the final analysis. The study's findings highlight several key barriers that impede the adoption of BIM-based risk management. These barriers include data interoperability, software compatibility, the lack of standardised protocols, limited awareness, resistance to change, inadequate training and skill development, legal and contractual constraints, fragmented project delivery processes, and insufficient collaboration among stakeholders. Furthermore, the study employs bibliometric analysis techniques to identify frequent keywords, top countries, publication sources, and emerging research trends. This analysis provides a holistic view of the research landscape and helps identify potential avenues for further investigation. By synthesising the existing literature and providing a comprehensive analysis of the barriers to adopting BIM-based risk management, this study offers valuable insights for researchers, practitioners, and policymakers. The findings can inform the development of strategies and interventions to overcome these barriers and promote the effective implementation of BIM technology for risk management in the construction industry.

Ultimately, this research contributes to the advancement of BIM adoption and enhances construction projects' overall performance and sustainability.

Keywords: Adoption, Barriers, BIM, Construction, Risk Management

1.0 BIM-Based Risk Management in the Construction Industry

The construction industry significantly influences the built environment, which promotes societal advancement and economic growth. Numerous studies have established the importance of the construction industry in terms of Gross Domestic Product (GDP), economic and infrastructural development, and employment creation (Bello *et al*., 2023a; Bello *et al*., 2023b; Aka *et al.*, 2022; Ahmad *et al*., 2022; Olanrewaju *et al*., 2020; Rabia *et al*., 2020; Isa *et* al., 2016; Isa *et al.*, 2013). According to Bello *et al.* (2022), the construction industry's contribution to global economic development has the potential to increase in terms of the gross domestic product (GDP) over the years.

However, the construction industry is also inherently complex and fraught with various risks and uncertainties. Effective risk management ensures project success, minimises costly errors, and enhances overall performance (Ehsan *et al.*, 2010). In recent years, Building Information Modelling (BIM) has emerged as a promising technology that can revolutionise risk management practices in the construction industry. BIM, which includes geometric and non-geometric data, is a digital representation of a construction or infrastructure project. Stakeholders can jointly design, visualise, simulate, and analyse various project elements (Musa *et al.*, 2019; Panuwatwanich *et al.*, 2013). Due to its ability to better communication, decrease errors and rework, improve project coordination, and speed up decision-making processes, BIM has received a lot of interest and adoption in the construction sector (Musa *et al.*, 2019).

BIM is more effective than conventional methods in risk management in several ways. As a result, proactive risk mitigation measures can be used to identify and evaluate potential risks from the earliest design stages. Project teams can visualise (Grilo & Jardim-Goncalves, 2010) and assess the impact of risks on several project parameters, such as cost, time, and safety, by including risk analysis into the BIM model (Zhang & Hu, 2011; Hardin, 2011). Additionally, BIM improves collaboration and communication among project stakeholders, enabling a more comprehensive and integrated approach to risk management (Musa *et al.*, 2019). Despite the

potential benefits, the widespread adoption of BIM-based risk management practices in the construction industry faces significant barriers. Understanding these barriers is crucial for researchers, practitioners, and policymakers to develop effective strategies to overcome them and promote the successful implementation of BIM technology.

Technological challenges significantly hamper the adoption of BIM in risk management. The absence of data interoperability and integration across the various software platforms used in the construction sector is one of the major problems (Azhar, 2011). Architects, engineers, contractors, and subcontractors must all share correct and current information for BIM to function. However, different software platforms, a lack of software compatibility, inconsistent data formats, and a lack of interoperability make it difficult to work together seamlessly and effectively to control BIM risks (Chieng *et al.*, 2014). In addition, there are considerable difficulties in implementing BIM because there are no standardised standards or guidelines (Tomek & Matejka, 2014). Diverse stakeholders in the construction sector adhere to various procedures and standards within a disjointed environment. Sharing and analysing risk-related information is inconsistent and challenging since BIM adoption and risk management practises are not uniform. To overcome these technical hurdles, the industry must establish standards and guidelines for BIM-based risk management.

Adoption of practises for risk management based on BIM is also hampered by organisational constraints. A lack of knowledge and comprehension of BIM's potential benefits for risk management is common among construction businesses and experts (Dim *et al.*, 2015). The readiness to invest in BIM technology and adopt novel risk management strategies is hampered by resistance to change and a preference for established methods. The slow adoption of risk management techniques based on BIM is also a result of poor training and skill development among project teams (Azhar *et al*., 2012). An all-encompassing strategy involving change management techniques, education, and training is needed to address these organisational hurdles.

Implementing BIM-based risk management in the construction sector is further complicated by contextual constraints. Construction projects' complexity and dynamic nature, which involve numerous stakeholders, shifting specifications, and shifting project factors, are their defining characteristics (Mustaffa *et al*., 2020). Adopting BIM is further complicated by legal and

contractual restrictions like those involving responsibility and intellectual property rights (Mustaffa *et al*., 2020). Additionally, the fragmented supply chains and varied project delivery methodologies in the construction industry make it difficult for stakeholders to collaborate effectively and share information (Mahmud *et al*., 2019). It is essential to have a comprehensive approach that considers the particulars of construction projects and promotes cooperation and integration among stakeholders to overcome these contextual hurdles.

An extensive literature study and bibliometric analysis of the available studies are necessary to understand these obstacles better and guide mitigation actions. Such an analysis identifies the current level of knowledge, the leading nations researching this subject, keyword occurrence and publication sources, research trends, and prospective future research in the domain of BIM-based risk management in the construction sector. In order to give a thorough picture of the obstacles to adopting BIM-based risk management in the construction sector, a systematic evaluation of the literature and bibliometric analysis were done. The study looks for common themes, trends, and areas of concentration in the existing research by synthesising and examining a wide range of scholarly literature. This analysis aids in laying a solid foundation for comprehending the difficulties preventing the broad use of BIM technology for risk management objectives.

The bibliometric analysis provides quantitative data on the most participating nations, keyword occurrence, article sources, and publications on the subject as a complement to the systematic literature review. With this analysis, future research into BIM-based risk management can be guided by the developing research trends and prospective research gaps. It will make it possible for academics, professionals, and decision-makers to stay up to date on the most recent developments, work together with important constituencies, and consider cutting-edge approaches to overcoming the barriers the study revealed. This study intends to offer insightful information about the obstacles preventing the adoption of BIM-based risk management in the construction sector by synthesising the results of the systematic literature review and bibliometric analysis. The findings can help create strategies, initiatives, and policies that can encourage the efficient application of BIM technology for risk management objectives. Ultimately, this research advances the use of BIM in the construction sector, enhances risk management procedures, and improves construction projects' general efficiency and sustainability.

2.0 Methodology

Through a thorough assessment of the literature and bibliometric analysis, this study aims to investigate and analyse the obstacles to adopting BIM-based risk management in the construction industry. Data was collected through a search to find pertinent academic articles about BIM-based risk management in the construction industry through the Scopus database. The search command used is "barriers to adoption of BIM-based risk management in the construction industry" to get the result of 2070 articles. Pre-established inclusion and exclusion criteria were used to screen the identified literature, as shown in Figure 1. A thematic analysis was carried out to find common themes and patterns relating to adopting BIM-based risk management. The highlighted themes were grouped and organised to give a thorough overview of the barriers.

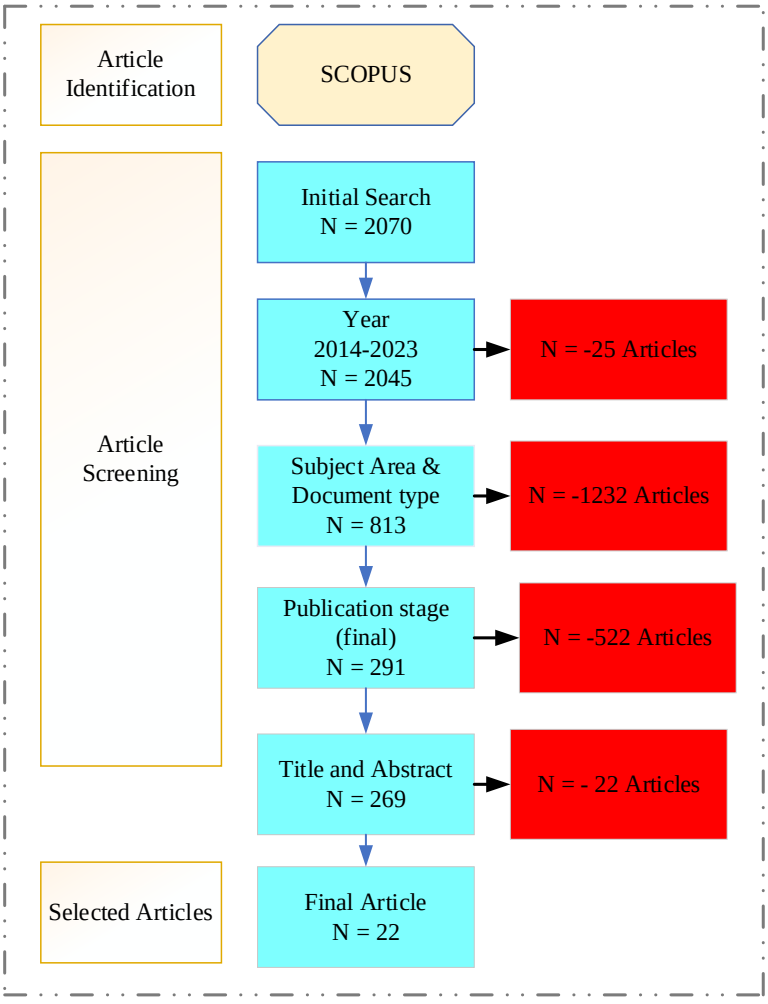

Figure 1. Article Selection Process

In order to identify keywords, countries, publication sources, and publications in the field of BIM-based risk management, critical bibliometric measures, including citation counts and documents, were analysed. Network visualisation techniques, including country and keywords networks, were used to comprehend the research community's collaboration patterns and information flow.

3.0 Barriers to BIM-Based Risk Management in the Construction Industry

BIM has become a game-changing technology in the building sector, providing several advantages for project planning, design, and construction. BIM promotes cooperation and enhances decision-making through the production, management, and interchange of digital representations of a building throughout its life. The implementation of BIM-based risk management practises in the construction sector, despite the potential benefits of BIM, confronts several challenges.

Technological obstacles significantly hamper the limited uptake of BIM-based risk management in the construction sector. These obstacles generally result from a lack of data interoperability, difficulties integrating new technologies, and information fragmentation across the many software platforms the sector employs (Azhar *et al*., 2012). Data interoperability is the seamless interchange and interpretation between various software tools and systems. BIM-based risk management combines risk-related data from many sources, including design models, construction timelines, and cost estimates, into a single BIM model. The inability of these various sources of information to be effectively integrated and interoperable is hampered by the lack of standardised protocols and formats for data sharing (Tomek & Matejka., 2014).

Data fragmentation results from the wide variety of software programmes and technologies that many stakeholders use throughout a construction project (Zou *et al*., 2017). As an illustration, architects might use one software platform for design modelling. In contrast, contractors might use another software for cost estimation. Conducting thorough risk analysis and mitigation is made significantly more difficult by the inability to easily combine these many software tools and share data consistently and relevantly. Additionally, compatibility problems occur when BIM technology is attempted to be integrated with current legacy systems and software platforms utilised by professionals in the building industry. These older technologies might not be able to handle the essential file formats or data structures for efficient risk management and

collaboration in a BIM environment. As a result, experts could use manual information entry and transfer, which results in mistakes, duplications, and inefficiencies. The creation of open standards and increased software tool compatibility are necessary to overcome these technological obstacles. The industry must create standardised data transmission and interoperability protocols to ensure that various software programmes can connect without interruption. Projects like the Industry Foundation Classes (IFC) and Construction Operations Building Information Exchange (COBie) strive to establish standardised data formats and schemas to make interoperability and integration easier.

Implementing BIM-based risk management in the construction industry is hindered by organisational hurdles, which are crucial factors. These obstacles are brought on by a lack of knowledge, resistance to change, and worries about the expense and disruption of ongoing workflows (Chen *et al*., 2015). A typical organisational hurdle is a lack of knowledge about the potential advantages of BIM-based risk management among construction businesses and specialists (Arayici *et al*., 2011). The benefits of BIM technology for enhancing risk management procedures and project outcomes may not be fully appreciated by many industry players (Bosch-Sijtsema *et al*., 2019). This lack of knowledge may be caused by several factors, such as the absence of BIM from educational curricula, restricted access to training opportunities, and a lack of knowledge regarding practical BIM risk management implementations (Alfaro-González *et al*., 2019). Targeted awareness and education campaigns are needed to address this barrier. In order to spread the word about the advantages of BIM-based risk management and increasing awareness among construction professionals, industry groups, professional bodies, and governmental organisations can be extremely helpful (Besné *et al*., 2021). Conferences, workshops, and training programmes can offer venues for exchanging knowledge and best practices. A culture of creativity and openness to change can be fostered by using case studies and success stories to raise awareness of the beneficial effects of BIM on risk management and to help overcome ignorance. Adopting BIM-based risk management is hampered by organisational resistance to change, another significant hurdle.

Construction companies and professionals could be hesitant to engage in BIM technology because they are worried about the price, perceived complexity, and potential disruptions to current operations (Onungwa *et al*., 2017; Walasek & Barszcz, 2017; McAuley *et al*., 2017). Key

decision-makers may resist departing from established practices and procedures (Tan *et al*., 2019; Ademci & Gundes, 2018). Building a solid business case for BIM-based risk management is essential to overcoming this hurdle. To overcome reluctance to change, it might be helpful to present the ROI and highlight the long-term benefits, such as increased project efficiency, decreased rework, and more significant risk mitigation. Pilot projects and phased deployment strategies can also be used to gradually introduce BIM technology and allow stakeholders to see its advantages first-hand. It is possible to allay their worries and win support for implementing BIM-based risk management by talking to and including critical decision-makers in the decision-making process.

Organisational concerns about cost hinder the adoption of BIM-based risk management. It can be necessary to make early investments in hardware, software licences, training, and infrastructure to implement BIM technology and incorporate risk management procedures (Azhar, 2011). Particularly for small and medium-sized construction enterprises, it may be difficult to dedicate resources to implement BIM due to financial restrictions. Governments and trade groups can offer financial incentives and other support systems to promote adopting BIM technology to overcome this obstacle (Bello *et al.*, 2022; Hamma-Adamma, 2020). The financial burden can be lessened, and BIM can be more easily accessed by a more extensive range of construction enterprises with funding programmes, grants, and subsidies. Collaboration between the public and commercial sectors can also result in the creation of affordable BIM systems and shared resources that lower the cost barriers to adoption (Hamma-Adamma, 2020).

Summarily, there are considerable obstacles in the way of the construction sector adopting BIM-based risk management. The widespread use of BIM technology for efficient risk management is hampered by a lack of awareness, opposition to change, and cost considerations. Contextual obstacles to implementing BIM-based risk management in the construction sector are connected to the institutional and organisational context of project execution. These obstacles include organisational resistance, a lack of knowledge, subpar procurement procedures, and scant government assistance. Adopting novel technologies like BIM is frequently hampered by organisational resistance to change. Due to worries about costs, interruption to current processes, and the requirement for training and upskilling, many construction businesses are reluctant to invest in BIM. A lack of knowledge of the potential advantages of BIM-based risk management

may cause this opposition. Creating a solid business case demonstrating the return on investment and emphasising the long-term advantages of better risk management and project results will help overcome organisational opposition (Abanda *et al*., 2017).

Another contextual hurdle is that stakeholders are not aware of the possibilities of BIM for risk management. The knowledge of BIM and its uses for risk analysis and mitigation among construction professionals, including owners, architects, engineers, and contractors, may be inadequate. Stakeholders may not prioritise BIM implementation if they do not have a comprehensive understanding of its capabilities and advantages. Therefore, addressing industry experts with awareness and training programmes is essential to removing this obstacle (Olanrewaju *et al.,* 2020). Such programmes might exhibit adequate case studies and real-world examples of BIM-based risk management to show its value (Fadzil *et al.,* 2021). Contextual obstacles to adopting BIM-based risk management are also a result of poor procurement procedures. It might be difficult to effectively collaborate and integrate risk management processes using traditional procurement approaches that prioritise the lowest cost and segregate contractual relationships among project participants (Tan *et al*., 2019). The capacity to use BIM for risk analysis and mitigation is constrained by the lack of early involvement of important stakeholders and the absence of integrated project delivery systems.

According to Shen *et al*. (2019), embracing collaborative procurement techniques like integrated project delivery (IPD) or design-build can aid in removing this obstacle by encouraging a culture of cooperation and shared risk among project participants. Contextual obstacles include a lack of government backing, policies that encourage the use of BIM, and risk management practices (Wang *et al*., 2015). By setting legislation, introducing financial incentives, and pushing industry-wide standards, governments can play a significant part in fostering the adoption of BIM. Its widespread adoption is hampered by inconsistent support across jurisdictions and the absence of comprehensive policies tailored to BIM-based risk management. To encourage the fusion of BIM and risk management, governments must establish supporting regulations, actively interact with industry stakeholders, and provide funding (Jallow *et al*., 2020). Contextual barriers call for a complex strategy, including numerous parties. Construction companies should fund organisational change management procedures.

Through conferences, seminars, and training initiatives, industry groups and professional bodies can help to advance awareness and knowledge exchange. Government organisations must set rules, offer financial incentives, and work with industry stakeholders to create comprehensive policies and standards. Finally, organisational opposition, a lack of knowledge, poor procurement procedures, and insufficient government assistance are some contextual hurdles to implementing BIM-based risk management in the construction industry. Collaboration between building companies, trade associations, and governmental organisations is required to remove these obstacles. Contextual hurdles must be removed to encourage the widespread adoption of BIM-based risk management practices in the construction sector. These stages include raising awareness, creating compelling business cases, implementing collaborative procurement techniques, and adopting collaborative procurement methods.

4.0 Bibliometric Analysis

In order to study the quantitative and qualitative traits of scientific literature, bibliometric analysis is a valuable research technique. In order to do this, a group of academic articles must be analysed for patterns, trends, and linkages. A bibliometric analysis was undertaken as part of the study on "Barriers to Adoption of BIM-Based Risk Management in the Construction Industry" to learn more about the body of literature on the subject. A comprehensive search and review of pertinent scientific papers from databases (Scopus) was required for the bibliometric analysis. The search used the right keywords and inclusion/exclusion criteria to select the most pertinent papers. The chosen articles were further examined to draw out pertinent information, including publication year, citation counts, journals of publication, and keywords.

The study aimed to offer a thorough review of the body of knowledge on the issues that prevent the adoption of BIM-based risk management; thus, it conducted a bibliometric analysis. This analysis provides a basis for comprehending the existing state of research, identifying research gaps, and guiding future directions for academic inquiry in this area. Many advantages come from bibliometric analysis. It gives academics a methodical, unbiased way to review massive amounts of literature while allowing them to pinpoint the most significant and impactful studies. By emphasising new subjects and areas of interest, it also aids in the discovery of patterns and trends in research. Furthermore, bibliometric analysis simplifies identifying important

institutions, groups, and collaborations, advancing knowledge sharing and strengthening research networks.

4.1 Publication based on countries

Countries having a minimum of two articles are considered for this study. Table 1 shows the country's representation based on the number of documents and citations. The countries were ranked based on the highest to lowest number of citations. The result shows that the United Kingdom has the highest number of documents (5), and the United States has the highest number of citations (401). This finding similarly corresponds with Vuksic *et al*. (2018) asserting that digital technology research emanates from advanced countries. The study further reported this finding (Douglas *et al*., 2020). The result also agrees with the 2022 Institute of Management Development report, "world digital competitiveness" ranking, which shows the identified are ranked. Based on their ranking, the United States was ranked second on the list after Denmark, which was ranked first. Hong Kong ranked (9), United Kingdom (16), Australia (14), and China (17). A careful comparative study of the 2021 and 2022 rankings shows that the five countries reported in this study have dropped ranks in the 2022 ranking except for Australia, which was previously ranked 20th in 2021 and ranked 14th in the 2022 ranking. This implies that other countries are continuously and significantly working towards digital advancement. However, it is worth noting that the top countries on the list are advanced. Developing countries, especially African countries, are not significantly represented in the ranking. This lapse creates a research gap in investigating the list's insignificant representation of African countries. Figure 1 shows the VOSviewer overlay of the relationship between the countries.

Table 1. Countries of publication

ID	Country	Documents	Citations	Total Link Strength
1	United States	4	401	2
2	Hong Kong	4	277	2
3	United Kingdom	5	163	2
4	Australia	2	121	2
5	China	4	86	2

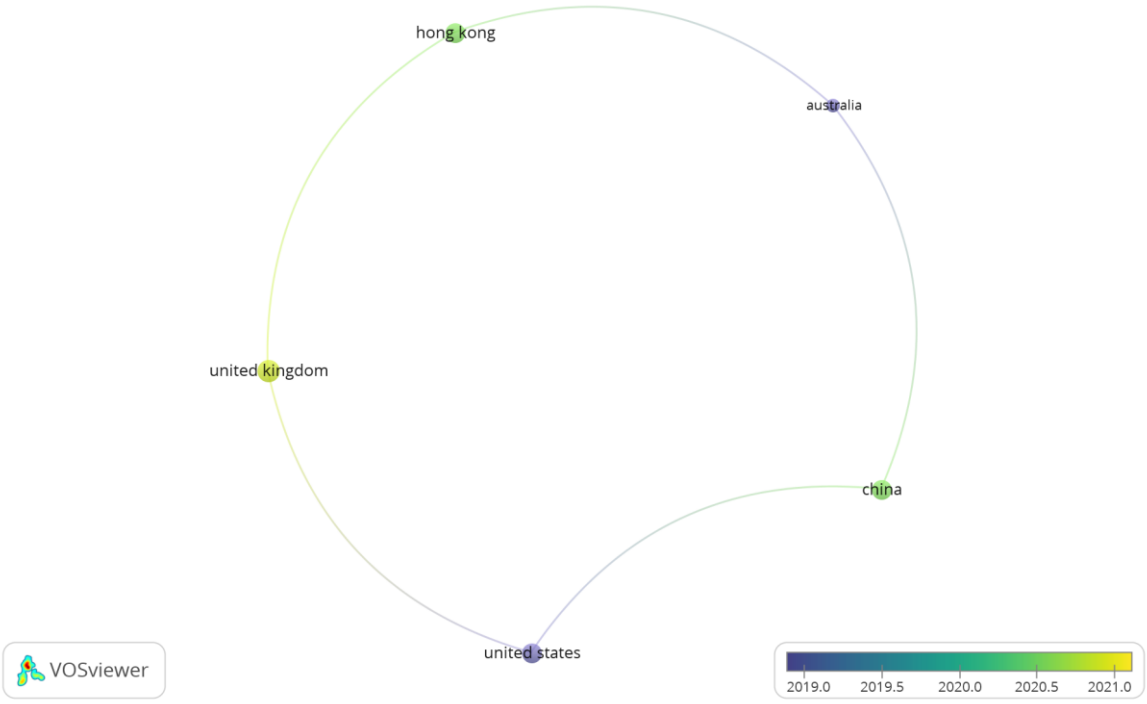

Figure 1: Overlay Visualisation of Countries

4.2 Keywords Co-occurrence

This study adopts a minimum number of occurrences for keywords to be 2. Out of the 199 total keywords from the result, only 27 meet the threshold. This same approach and minimum threshold (2) have been adopted in the study of Saka and Chan (2019). Figure 2 shows the network visualisation map for the 27 co-occurring keywords and their three various clusters. In the centre of the map is the keyword "building information modelling", which is connected to all other keywords. The clusters were named "Construction and Information", "Management and Methodology", and "Construction and Project Management".

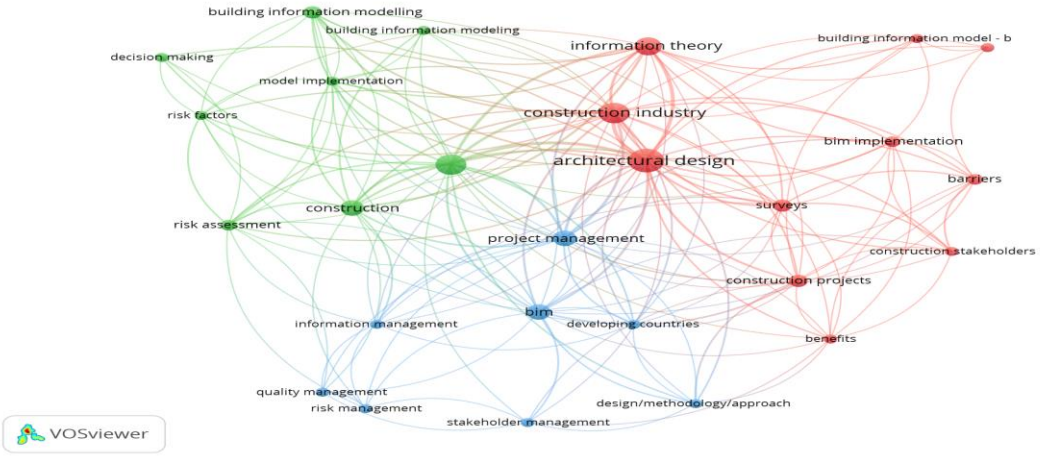

Figure 2. Keywords Co-occurrence

4.3 Publication based on article source

The 22 papers were published in eleven journals, with documents per source ranging between 1-5 publications. Figure 3 shows sources with a minimum of one publication. The justification for benchmarking the criteria to one document is that a single article can have numerous citations in some cases. Such as the case with the "International Journal of Building Pathology and Adaptation" and "The Asian Journal of Civil Engineering" have 10 and 6 citations per document, respectively. Automation in Construction tops the list with five publications and 549 citations. This finding also correlates with the result of Douglas *et al*. (2020). According to Douglas *et al*., 2020 automation in construction focuses on investigating the use of information technology for the design, engineering, construction technologies, management, and maintenance of construction facilities. Journal of Building Engineering is ranked second on the list with five documents and 447 citations; Advances in Civil Engineering with two documents and 14 citations; International Journal of Building Pathology and Adaptation with one document and ten citations; and Asian Journal of Civil Engineering with one document and six citations.

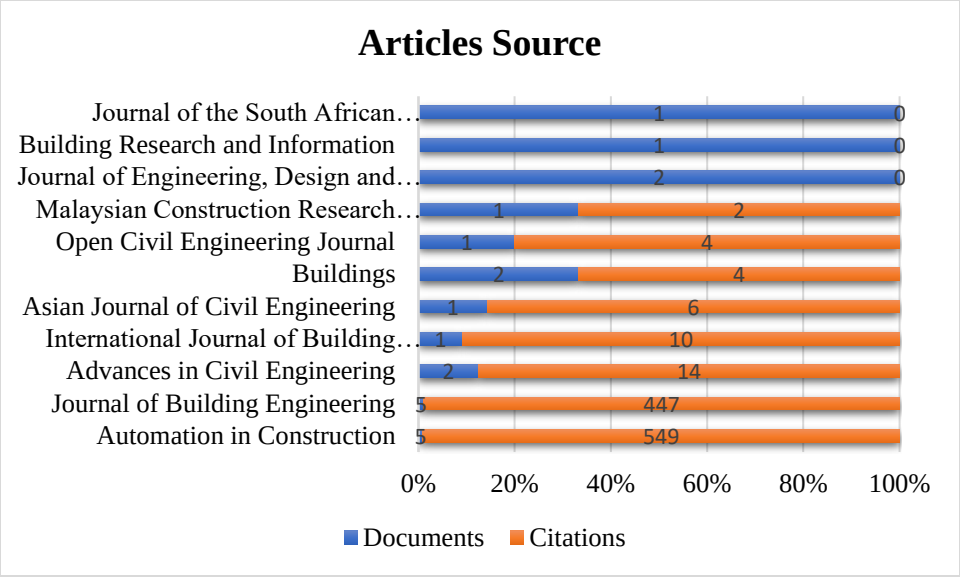

Figure 3. Article Source

4.4 Article Affiliation

Table 2 shows the top five contributing institutions to BIM-Based risk management in the construction industry. The Hong Kong Polytechnic University was ranked the highest contributor having 272 citations. This finding aligns with the study of Douglas *et al*. (2020), which ranked Hong Kong Polytechnic University as the highest contributor to C4.0 and SD research. Other top contributing institutions include The State University of New York, the University of Florida, and Michael Baker International, all having one document and 243 citations. Furthermore, National Central University has one document with 190 citations.

Table 2. Affiliation of publication

S/N	Affiliation	Documents	Citations	Total link strength
1	Department of Building and Real Estate, Faculty of Construction and Environment, the Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong	2	272	1
2	Department of Civil, Structural and Environmental Engineering, The State University of New York at Buffalo, United States	1	243	2
3	School of Construction Management, University of Florida, P.O. Box 115703, Gainesville, fl 32611, united states	1	243	2
4	Michael Baker International, 100 Airside dr., Moon Township, PA 15108, United States	1	243	2
5	Department of Civil Engineering, National Central University, Taoyuan, Taiwan	1	190	1

5.0 Discussion

The study's findings shed important light on the construction sector's challenges in adopting BIM-based risk management. This study has identified and analysed the main obstacles to adopting BIM technology for risk management objectives by systematically examining the literature and bibliometric analysis. The main discussion points are the study's principal findings and how they affect policy, practice, and research. The technology barrier was one of the crucial hurdles found in this investigation. The disparate software platforms hamper effective risk management with BIM utilised in the construction industry's lack of data integration and interoperability. This conclusion, per earlier research (Shen *et al*., 2019; Abanda *et al*., 2017), emphasises the requirement for standardised protocols and guidelines for data integration and interchange. Open standards must be created to overcome this technological barrier, and software tool compatibility must be increased for easy information sharing and cooperation.

The organisational reluctance to change is another significant hurdle. Lack of understanding of BIM's potential benefits for risk management among many construction businesses and experts

prevents them from investing in the technology and using novel risk management strategies. Targeted awareness and training campaigns to inform stakeholders of the benefits of BIM-based risk management are necessary to overcome this hurdle. Making a compelling business case and showcasing the ROI can reduce organisational resistance and promote an innovative and adaptable culture (Shen *et al*., 2019; Yu *et al*., 2018). A significant hurdle to adopting BIM and risk management practices is the absence of industry-wide standards and guidelines. This result is consistent with other research (Jallow *et al*., 2020; Fadzil *et al*., 2021), and it emphasises the necessity for standardisation initiatives to guarantee consistency and interoperability in BIM-based risk management methods. Effective risk analysis and mitigation measures can be made possible by creating and adopting industry-wide standards and guidelines.

The barriers that have been identified have an array of effects on research, practice, and policy. In terms of research, this study adds to the body of knowledge by giving a thorough and current summary of the obstacles to adopting BIM-based risk management. These results can be a starting point for more research into particular barriers, their root causes, and potential remedies. Future studies should concentrate on creating frameworks and strategies to overcome these obstacles and improve the use of BIM technology for risk management in the construction sector.

The study's results are quite practical for building companies and experts involved in risk management procedures. Organisations may strengthen their risk management procedures and build effective strategies to overcome these obstacles by clearly understanding the hurdles to BIM adoption. For instance, businesses can spend money on training courses to improve the workforce's proficiency with risk management techniques and BIM technologies. Additionally, incorporating risk management procedures into the BIM workflow can be facilitated through collaboration across stakeholders, including designers, contractors, and owners. The barriers that have been identified demand the creation and execution of helpful legislation and policies. Governments and trade organisations must actively encourage BIM to use and support risk management procedures in the building sector. This is possible by creating national BIM standards, financial incentives, and legal frameworks that support the use of BIM technology for risk management. Integrating BIM-based risk management requires a collaborative effort between the public and commercial sectors.

6.0 Conclusion

The study's findings shed important light on the construction sector's challenges in adopting BIM-based risk management. This research has discussed the major obstacles preventing the broad adoption of BIM technology for efficient risk management. These obstacles were discovered using a systematic literature review and bibliometric analysis. The study has highlighted the organisational, standardisation and technological challenges that must be overcome to encourage the industry to embrace BIM-based risk management practices. The results of this investigation have broad ramifications. The results can be a starting point for additional research into specific barriers, underlying causes, and potential remedies. Construction companies and experts who can create plans to overcome these obstacles and improve their risk management procedures are affected practically. Some actionable approaches include risk management process integration within the BIM workflow, stakeholder participation, and training initiatives. The creation and execution of supportive policies and regulations are required due to policy implications. By creating national BIM standards, financial incentives, and legal frameworks, governments and industry organisations should actively encourage the adoption of BIM and facilitate risk management practices. Collaboration between the public and commercial sectors is essential for BIM-based risk management to be successfully adopted.

7.0 Future Studies Directions

i. Investigation of strategies to address technological barriers: The study brought attention to technological obstacles like problems with data exchange, software integration, and compatibility. Future studies could examine and create efficient ways to get around these obstacles. For seamless information interchange, this may entail the creation of standardised data formats and protocols, improving interoperability frameworks, and incorporating cutting-edge technologies like artificial intelligence and machine learning into BIM-based risk management procedures.

ii. Exploration of context-specific barriers: The contextual obstacles mentioned in the study, such as organisational resistance, a lack of knowledge, poor procurement procedures, and a lack of government backing, may differ depending on the organisational context and the location. Future research can go into further detail to identify the particular contextual hurdles that particular locations or different types of construction organisations must overcome. As a

result, it will be possible to build specialised tactics to overcome these obstacles and gain insight into regionally unique difficulties.

iii. **Assessment of the economic benefits of BIM-based risk management:** Future research can concentrate on conducting empirical studies to quantitatively analyse the economic benefits of adopting BIM-based risk management, even though the study covered the potential advantages of such risk management. In order to do this, project data may be analysed and performance indicators between projects that adopted BIM-based risk management and those that did not may be compared. Such studies can give stakeholders verifiable proof of the benefits and return on investment of implementing BIM-based risk management procedures.

iv. **Examination of the role of regulations and policies:** The study emphasised the significance of government assistance and policies to encourage BIM-based risk management. Future studies can look into how standards, incentives, and laws affect how BIM and risk management are integrated into construction projects. In order to do this, it may be necessary to examine the effects of government initiatives and policy frameworks on adoption rates, identify best practices for policy implementation, and evaluate the efficacy of various policy approaches in various circumstances.

v. **Evaluation of the human factors in BIM-based risk management:** The report mentioned organisational obstacles, such as a shortage of qualified personnel and opposition to change. Future studies can explore the human variables affecting the acceptance and successful application of BIM-based risk management. Some possible approaches are studying the variables that affect BIM adoption among construction professionals, identifying the critical abilities and skills necessary for implementation success, and investigating efficient change management and training programme methodologies.

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