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Barriers to Automation and Robotics in Construction: A Scientometric and Thematic Review

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Abstract

The construction industry plays a vital role in the economic and infrastructural development of nations. Nevertheless, it continues to face persistent challenges such as stagnant productivity, poor safety performance, and declining quality due to its heavy reliance on manual labor. Automation and robotics offer significant potential to address these issues and enhance construction efficiency. However, their adoption within the construction sector remains limited by various barriers. This study adopts a scientometric approach to review relevant literature retrieved from the Scopus database between 2000 and 2025. Using VOSviewer, the study analyzes publication trends, research hotspots, and the contributions of countries and journals. The thematic analysis identified and categorized the barriers into six major groups: policy and regulatory, environmental and social, organizational and managerial, knowledge and human, economic and financial, and technical barriers. This categorization provides a structured understanding of the constraints hindering technological advancement in the industry. The study contributes to ongoing discourse on research and development initiatives aimed at integrating automation and robotics into construction. It recommends the formulation of clear policies and standards, investment in skill development, financial incentives, and stronger collaboration between public and private sectors as key strategies to mitigate these barriers.

Keywords
Barriers, Automation and Robotics, Construction Industry, Scientometric, Exoskeleton

1. Introduction
The construction industry plays a vital role in the economies of most countries (Huang *et al.*, 2022), second only to farming. (Jayaraj & Divakar, 2018); Ngcobo & Akinradewo, 2023). It's essential for societal progress and enabling important development projects and infrastructure improvements. However, with increasing urbanization and a growing population, the need for more infrastructure is constantly rising. The increase in demand for more infrastructure is a global challenge that needs to be addressed to achieve the Sustainable Development Goals. Meeting this need effectively requires improvements in efficiency and accuracy, which can be difficult to achieve using conventional construction methods. (Sadiku et al., 2025).

Despite its importance to the economy and development, the construction industry faces many problems. These include a lack of efficiency, decreasing quality, inadequate safety measures, and undesirable working environments. (Bock, 2007; Bogue, 2018). These issues have slowed down progress and led to lower productivity compared to industries like manufacturing (Ajayi, 2025). The construction industry also lags in adopting digital technologies, and many within the industry are hesitant to embrace change (Delgado et al., 2019); Oke, et al., 2023a). suggest that traditional construction techniques are no longer as effective as they could be. They believe that incorporating automation and robots is a good way to address the construction industry's ongoing struggles with productivity.

The integration of technology and robotics, commonly referred to as automation within the construction industry, serves to enhance various stages of project development, including design conceptualization, strategic planning, and budgetary projections (Saidi, Bock, and Georgoulas, 2016). Today, different types of robotic and automated systems are used in construction, but there's no single standard way to categorize them, as ongoing technological progress often makes the distinctions unclear (Oke et al., 2023). One approach, suggested by (Bock, 2015), categorizes construction robots by when they're used in the construction process, dividing them into drones and self-driving vehicles, exoskeletons, systems for building components off-site, and automated and robotic systems for use on the construction site itself.

The advantages of using robots in construction are well-recognized. Many studies show they can help solve some of the industry's long-standing problems. For instance, (Huang et al. 2022; Yao et al. 2025) believe automation will be very important in the future of construction, making it safer, more efficient, and more innovative through careful investment, teamwork, and helpful regulations (Tafazzoli, Shrestha and Dang, 2024; Ding *et al.*, 2025). Likewise, (Oke, et al., 2023a; Zeng et al., 2024; Xu et al., 2025)point out that robots and automation can make projects safer by being more accurate, reducing mistakes, and lowering the number of accidents, which improves overall productivity. On construction sites, robotic arms can now do things like laying bricks, assembling steel structures, welding, installing facades, and pouring concrete(Xiao, et al., 2022; Liang et al., 2024). In these areas, robots have proven to be faster and more precise than human workers, leading to a significant increase in productivity. (Pan et al., 2018; Patel et al., 2024)

Globally, researchers have investigated the implementation of automation and robotics in countries like the United States, Australia, and Malaysia (Mahbub, 2008; Pradhananga et al., 2021), and China (Yao *et al.*, 2025). Despite technological progress and reported benefits, the construction industry, especially in developing nations, largely depends on conventional methods and is slow to embrace robotics. Several factors impede the integration of these technologies, including the relative newness of construction robotics, significant initial cost, a lack of uniformity, and the complex nature of construction sites (Cai *et al.*, 2020; Huang *et al.*, 2022). Social attitudes also contribute, as some view robotics as a potential threat to jobs and established work practices (Umesh and Sindhu, 2023). These common problems highlight the need to re-evaluate and improve current construction practices. In this situation, using robots and automated processes, which can reduce mistakes and minimize human intervention, looks like a good way to tackle the continuing difficulties faced by the construction industry.

Boosting productivity and advancing technology in construction is a worldwide goal. This can be accomplished by thoroughly understanding the barriers to adopting robotics in the construction industry. Therefore, this review aims to contribute to the body of knowledge by identifying the obstacles affecting the adoption of automation and robotics in the construction industry with a systematic review of relevant literature related to the field of study.

2. Benefit Of Automation and Robotics in Construction

Construction robots are gaining traction because they offer clear benefits. Studies such as (Pan *et al.*, 2018) show that innovations with obvious advantages are more readily adopted. These robots promise environmental, economic, and social improvements, especially in safety, efficiency, and sustainability (Skibniewski and Zavadskas, 2013; Cai *et al.*, 2018). The construction industry relies heavily on manual labor, which involves physically demanding tasks that can lead to injuries and health issues (Oke, et al., 2023; Akindele et al., 2024). However, automated systems, like bricklaying robots and material-handling machines, have been reported by (Bogue, 2018; Delgado *et al.*, 2019) to improve efficiency and project outcomes. Drones are also reported by (Akindele et al., 2024; and Khan et al., 2024). as valuable for site monitoring and safety management. Exoskeletons are another advancement, boosting workers' physical capabilities and reducing the risk of injury and fatigue (Mahmud et al. 2022). In the study of (Bock, et al., 2012) They are found to help with common problems like back pain and lessen the impact of an aging workforce. The significant safety and efficiency benefits of automation make its widespread use worth considering.

3. Research Methodology

This research utilizes a combination of quantitative and qualitative methods to thoroughly investigate the use of robotics and automation in the construction industry. On the quantitative side, a scientometric analysis of relevant publications is performed, and the bibliometric analysis was done using publications gathered from the Scopus databases. It examines patterns in publications, top journals, involved countries, organizations, and the contributions of key researchers in the field, thereby providing a comprehensive picture of research trends. the qualitative side involves a systematic examination and detailed discussion of barriers to adopting robotics in construction.

3.1 Data collection

After evaluating popular academic resources such as Scopus, Web of Science, and Google Scholar, this study determined that Scopus was the most effective choice for finding relevant research articles. As noted by,(Chadegani et al., 2013; Aghimien et al., 2020) Scopus is a relatively newer and rapidly expanding database, well-regarded within the scientific community, and has extensive coverage of construction engineering research, compared to other databases (Xiao et al., 2022), and has been selected as the primary data source in numerous prior literature reviews focusing on construction-related topics (Jin *et al.*, 2019). Regarding the search approach, various keywords connected to the subject of robotics in construction were identified to retrieve publication information from scopus covering the period from 2000 to may 2025. the terms used in our research process were as follows: (title-abs-key ("robotics" or "robotic") and title-abs-key ("construction industry" or "built environment")) and pubyear > 2000 and pubyear < 2025 and (limit-to (srctype , "j") or limit-to (srctype , "p")) and (limit-to (subjarea , "envi") or limit-to (subjarea , "engi")) and (limit-to (language , "english")). this timeframe represents the evolution period of robotics in the construction industry. the research focused on identifying the trends and development of robotics within the construction industry during this period. the initial selection of articles was then meticulously refined, concentrating on those related to construction and published in English. Next, the titles and abstracts of the downloaded articles were reviewed to remove any irrelevant papers or outside research scope. This is followed by the full text reading of the remaining articles. This screening process resulted in a final selection of 297 papers for further analysis.

3.2 Data analysis

Bibliometric analysis offers a broad view of a research area(Wang et al., 2020; Taiwo et al., 2023). Through the creation of maps and visualization, it shows the trend of research, contributions of research outlets, contributions of countries, authors, and the relationship between them. This is performed using the VOSviewer. this review also identified barriers to the adoption of automation and robotics in construction. These barriers were systematically taken from previous studies and then combined into larger groups to show patterns and connections. This grouping provided clearer insights into the barriers to robotics implementation. Ultimately, the synthesis of findings helped identify gaps in the current research. These gaps helped form recommendations and suggested possible future directions for better incorporating robotics into construction.

4. Results and Discussion

4.1 Publication trends

This section presents an illustration of the publication trends on automation and robotics in the construction industry. Figure 1. Depicts the number of publications recorded annually from 2000 to 2025. In another view, Figure 2 shows the trend of publications by decades. 7, 31, and 62% of the papers were published between 2000 and 2009, 2010 and 2019, and 2020 and the present, respectively. This trend shows the benefits and importance of automation and robotics in construction and a promising future for their development and evolution.

4.2 Key cluster analysis

This section details a keyword co-occurrence analysis, performed with VOSviewer, to reveal research trends within the domains of robotics and automation in the construction industry. From an initial 2,150 keywords extracted from 297 scholarly articles, 130 keywords met a predetermined frequency threshold of 5 occurrences. To enhance the robustness and precision of the analysis, closely related terminology was consolidated through the application of a thesaurus (e.g., unifying "robot" and "robotics"). The resultant bibliometric network diagram shown in Figure 3 elucidated five distinct clusters. A core "construction" cluster underscores the significance of robotics in bolstering operational output and effectiveness. Peripheral clusters investigate themes encompassing the assimilation of technology in emerging economies, the progressive digitalization facilitated by Building Information Modeling (BIM) and Artificial Intelligence (AI), and foundational technological components such as prefabricated building techniques and ecological considerations. Further clusters emphasize occupational safety, collaborative human-machine interaction, and improvements in workplace design, particularly the application of assistive technologies like exoskeletal devices. Table 1 presents the list of keywords with their occurrence and total link strength.

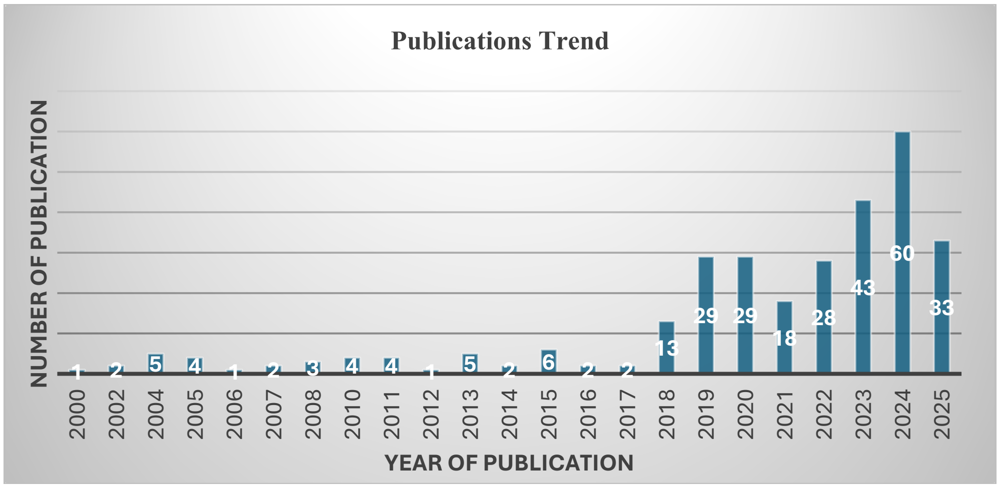

Figure 1. Publication trends per year

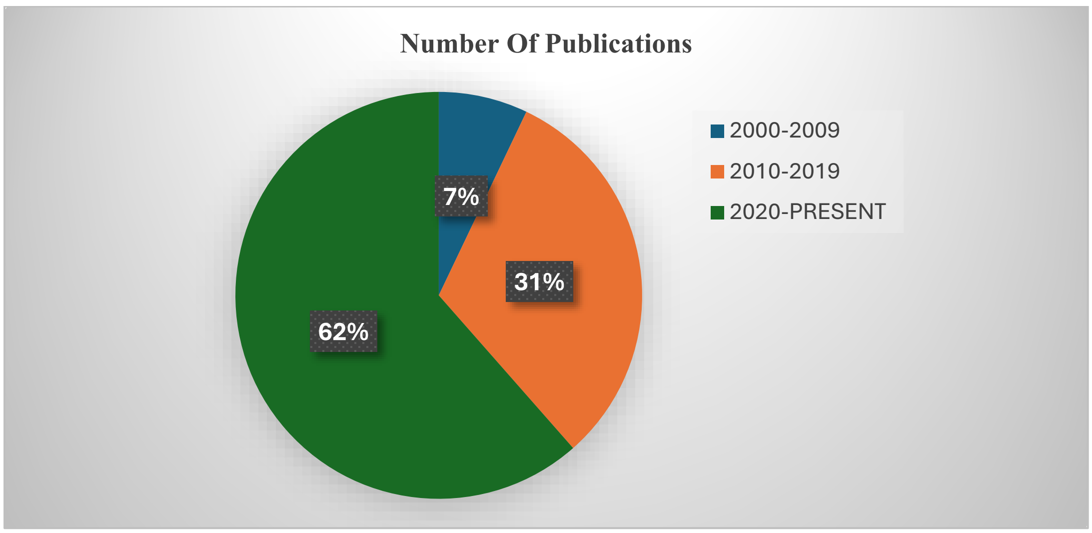

Figure 2. Percentage of publications per decade.

4.3. Contributions of Publication Outlets

The role of various journal houses was evaluated through a bibliometric analysis employing VOSviewer, focusing on their research output and influence. Stringent inclusion criteria were applied, requiring a minimum of five published articles and twenty-five citations per source. This approach facilitated the identification of the most prominent and productive publication outlets within the field, assisting researchers in discerning leading sources of scholarly impact. From an initial list of 146 journal houses, only 10 fulfilled these predefined criteria. The findings demonstrate that "Automation in Construction" emerged as the most significant source, characterized by its high volume of 30 publications, a considerable citation of 2,355, and a substantial total link strength of 44. These quantitative measures suggest that 'Automation in Construction" is the most significant outlet in robotics and automation publication within the construction industry, indicative of its considerable academic influence and the widespread recognition of the research output.

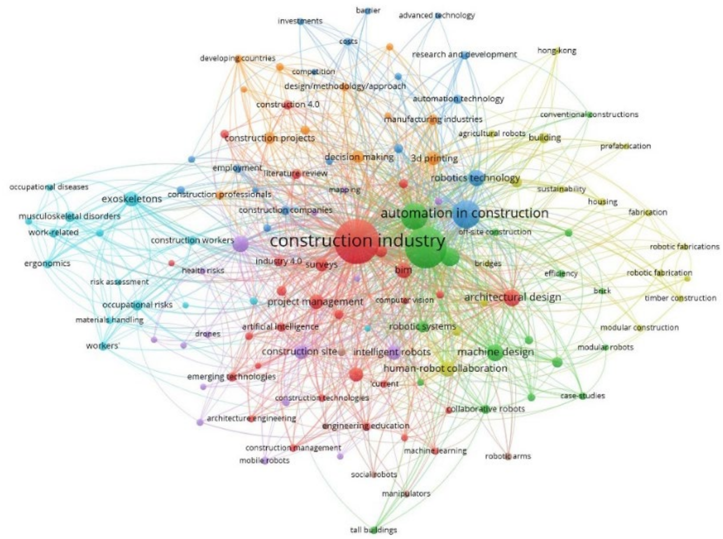

Figure 3. The network map of keyword co-occurrence. Source: Created on VOSviewer

4.4 Performance of Countries

This section presents the performance of countries on automation and robotics research in the construction industry. The criteria for inclusion are a minimum of 5 publications. The USA stands out as the most active country with the highest number of publications (88), the highest number of citations (1945), and the highest TLS (159). This is proof of its commitment to research and development, and collaborations with other countries on research in this field. The USA is followed by China, Australia, Germany, and Hong Kong in the first five countries. Also notable on the ranking are South Africa and Nigeria. This indicates their effort and commitment to research and development despite being a developing country.

4.5 Barriers/Challenges to the Adoption of Automation and Robotics in Construction

Although automation and robotics are often touted as beneficial for the construction sector, their widespread adoption remains limited. This gap in implementation has prompted considerable research into the obstacles and difficulties hindering their uptake. Studies examining these barriers have been conducted in various regions, including the United States (Pradhananga et al., 2021), Europe (Delgado *et al.*, 2019), Switzerland, (Chen *et al.*, 2016) Australia and Malaysia (Mahbub, 2008), India, (Patel, et al., 2024), and as well as Nigeria (Oke, Kineber, *et al.*, 2024). Have all explored the barriers and challenges to the adoption of automation and robotics in the construction industry. This section presents a comprehensive review and categorization of these barriers to inform proper understanding. The categorization of the barriers is shown in Table 1.

4.5.1 Technical barriers

This includes barriers related to the implementation of these technologies, as well as standard protocols and procedures for their adoption. Technicality or ease of implementation is a major factor in the adoption of any innovation. This includes Insufficient technical infrastructure, Difficulties of implementation in complex structures. According to (Oke et al., 2024) and (Delgado *et al.*, 2019). This deals with the limited availability of the hardware, software, and network systems that are needed to support robotics and automation technologies, especially in some developing countries where construction activities are carried out in remote areas. Other barriers in this category include Incompatibility with existing construction processes, Power/infrastructure issues, Adaptability and flexibility, and Variability of building types. In the report of (Huang et al., 2022), technological performance and management barriers, which include difficulty in using and understanding, a lack of integration with other technologies, difficulty in management on-site, and product complexity. is responsible for 20.403% of the variance analysis of the barriers to automation and robotics in construction. this corroborates the findings of (Oke et al., 2024), where technical-related barriers such as lack of technical infrastructure, unclear methodology of implementation, complexities of robotic technologies, and limited internet connectivity account for 6.044% of the total variance explained for the analysis of barriers to the implementation of automation and robotics, especially in developing countries. (Oke et al., 2024) reported that technology barriers are the most significant barriers to the implementation of automation and robotics in developing countries.

4.5.2 Economic and financial barriers.

Most investors, contractors, and developers who are major players in the construction industry will only adopt new technologies if they give them an edge in the form of profits(Mahbub, 2008). This gives them a guarantee over their investment as they are not ready to add to the existing risk of the construction process. These barriers occur in the form of High initial costs, high maintenance and upgrade costs, a lack of economic justification, limited or no government incentives, resource limitations, and low R&D investments. However, (Pan and Pan, 2020; Manpreet and Jeevanjot, 2024) Noted that the initial expenses and uncertain returns on investment are a big challenge for small and medium-sized companies. This is also the opinion of (Yamani Bin Yahya *et al.*, 2019). In the study of (Oke et al., 2024) Cost-related barriers account for 7.6% of the variance in the obstacles. This is also supported by (Patel et al.,2024) in his study of identifying Critical barriers using fuzzy DEMATEL, he identified high initial cost as the most influential barrier in order of their significance.

4.5.3 Knowledge and Human Barriers

To fully utilize automation and robotics for construction activities, relevant skills and technical knowledge are important across the board. There is a need to adequately train the workforce and construction professionals. The governments, construction companies, and contractors need to invest in the training of construction professionals to facilitate the implementation of these technologies in the construction industry. The notable barriers in this category identified in literature include Lack of skilled personnel, lack of adequate training, Lack of awareness of benefits, Resistance to change, and low awareness. (Oke *et al.*, 2025) reiterated that the lack of a database to improve awareness and knowledge about automation and robotics is one of the significant barriers to its adoption.

4.5.4 Organizational and Managerial Barriers.

Despite the reported benefits of automation and robotics to the construction industry, such as enhanced safety, improved productivity, and efficiency. The fragmented nature of the construction site and management of the construction industry is a major barrier to the implementation of automation and robotics.

According to Oke(Oke, Aliu, *et al.*, 2024)The organizational and managerial barriers, also known as industrial-related barriers, account for 28.345% of the total variance of barriers explained. Another related barrier in this category is the complexity of the supply chain, and this category accounts for 17.825% of the variance of the barriers explained by (Huang *et al.*, 2022). Other barriers reported in this category include Inconsistency in the structure of the construction industry(Pan *et al.*, 2020), Conflicts of interest between construction stakeholders(Mahmud *et al.*, 2022), Lack of standardized protocol and procedures(Mahbub, 2008; Ojha *et al.*, 2022) within the firm, and Diverse market requirements.

4.5.5 Environmental and social Barriers.

Social acceptance is a key to acceptance of any innovation. Many organizations will only adopt an innovation when a competitor has done so. And many construction firms are so accustomed to the traditional construction process. The risk-averse nature of the construction industry can prevent the adoption of construction robots (Wong *et al.*, 2018).
Also, there is a belief that automation will replace manual labor, resulting in unemployment, hence the reluctance to accept or implement automation and robotics in the construction industry. Environmental and social barriers occur in the form of Resistance from labor unions, market diversity, a variety of project environments, and Fear of Job displacement. Changes are associated with risks and uncertainties; many organizations and companies are reluctant to adopt automation and robotics due to uncertainty and perceived risk.

4.5.6 Policy and Regulatory Barriers.

The construction industry, especially in developing countries, faces significant barriers in adopting robots and automation due to existing regulations and policies. These problems largely arise from a lack of effective laws and organizational structures (Huang *et al.*, 2022) to support technological progress. When there are no clear and thorough official guidelines about how to use automated technologies, companies become reluctant to invest in robotic solutions. Furthermore, insufficient backing from industry groups and professional organizations (Delgado *et al.*, 2019; Patel, Bapat and Patel, 2024) limits the spread of information, standardized procedures, and promotes policy changes that foster innovation. The lack of governmental encouragement, like tax breaks, research funding, or reduced import costs for robotic equipment,(Bosede and Danjuma, 2024) also limits the interest of construction companies in adopting automation. The absence of a strong legal structure (Oke, Kineber, *et al.*, 2024) and unified organizational support creates a disorganized regulatory situation, which slows down adoption, leads to varying practices, and restricts the integration of technology into construction. Consequently, improving regulations and policies is crucial for establishing a supportive environment that encourages the successful use of robotics in construction.

Table 1: Categorization of the barriers

Category	Key barriers	Reference.
Technical barriers	Interoperability issues, Insufficient technical infrastructure, Difficulties of implementation in complex structures, Incompatibility with existing construction processes, Adaptability and flexibility, Variability of building types.	(Mahbub, 2008, 2012; Delgado *et al.*, 2019; Cai *et al.*, 2020; Trujillo and Holt, 2020; Huang *et al.*, 2022; Jäkel, Rahnama and Klemt-Albert, 2022; Amaifeobu, Iyamu and Adewunmi, 2023; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Oke, Kineber, *et al.*, 2024; Patel, Bapat and Patel, 2024; Tafazzoli, Shrestha and Dang, 2024; Ajayi, 2025; Ilesanmi *et al.*, 2025; Oke *et al.*, 2025)
Economic and financial barriers	High initial cost, High cost of maintenance and upgrades, lack of economic justification, Lack of or limited government incentives, and resource limitations., low R&D investments.	(Mahbub, 2008, 2012; Kamaruddin, Mohammad and Mahbub, 2016; Delgado *et al.*, 2019; Yamani Bin Yahya *et al.*, 2019; Cai *et al.*, 2020; Jäkel, Rahnama and Klemt-Albert, 2022; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Oke, Kineber, *et al.*, 2024; Patel, Bapat and Patel, 2024; Tafazzoli, Shrestha and Dang, 2024; Ilesanmi *et al.*, 2025; Oke *et al.*, 2025)
Knowledge and Human Barriers	Lack of skilled personnel and adequate training, Lack of awareness of benefits, Resistance to change, Low awareness,	(Mahbub, 2008, 2012; Kamaruddin, Mohammad and Mahbub, 2016; Delgado *et al.*, 2019; Yamani Bin Yahya *et al.*, 2019; Trujillo and Holt, 2020; Jäkel, Rahnama and Klemt-Albert, 2022; Amaifeobu, Iyamu and Adewunmi, 2023; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Oke, Kineber, *et al.*, 2024; Tafazzoli, Shrestha and Dang, 2024; Ajayi, 2025; Oke *et al.*, 2025)
Organizational and Managerial Barriers	Fragmented nature of the construction site, Complexity of the Supply Chain, Resource limitations of the companies, Inconsistency in the structure of the construction industry, Conflicts of interest between construction stakeholders, Lack of standardized protocol and procedures within the firm, and Diverse market requirements.	(Mahbub, 2008, 2012; Delgado *et al.*, 2019; Yamani Bin Yahya *et al.*, 2019; Huang *et al.*, 2022; Jäkel, Rahnama and Klemt-Albert, 2022; Amaifeobu, Iyamu and Adewunmi, 2023; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Oke, Kineber, *et al.*, 2024; Patel, Bapat and Patel, 2024; Oke *et al.*, 2025)
Environmental and social Barriers	Resistance from labor unions, market diversity, variety of project environments, Changes are associated with risks and uncertainties, Fear of Job displacement	(Mahbub, 2008, 2012; Delgado *et al.*, 2019; Yamani Bin Yahya *et al.*, 2019; Cai *et al.*, 2020; Trujillo and Holt, 2020; Huang *et al.*, 2022; Jäkel, Rahnama and Klemt-Albert, 2022; Amaifeobu, Iyamu and Adewunmi, 2023; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Oke, Kineber, *et al.*, 2024; Patel, Bapat and Patel, 2024; Tafazzoli, Shrestha and Dang, 2024; Ajayi, 2025; Ilesanmi *et al.*, 2025; Oke *et al.*, 2025)
Policy and Regulatory Barriers	Unclear legal framework, Inadequate support from industrial and professional bodies, lack of or limited government incentives, and lack of government policy.	(Delgado *et al.*, 2019; Cai *et al.*, 2020; Huang *et al.*, 2022; Bosede and Danjuma, 2024; Oke, Aliu, *et al.*, 2024; Patel, Bapat and Patel, 2024; Tafazzoli, Shrestha and Dang, 2024; Oke *et al.*, 2025)

5. Conclusion and Recommendations

This research investigated the patterns, technological transformation, and contributions of publication outlets and countries regarding the integration of automated systems and robotics in the construction industry. The analysis was performed using VOSviewer. Furthermore, a thorough review of existing literature was undertaken to identify the pertinent barriers to their adoption. The Scientometric analysis revealed that while developed nations have achieved considerable advancements through funding, research, and widespread use, developing nations still struggle due to the combination of obstacles. Nevertheless, countries including South Africa, Nigeria, India, and Pakistan have shown increased dedication through active research and development initiatives focused on incorporating automated systems and robotics into the construction industry. The thematic review result showed that these obstacles are complex, such as technical, regulatory, financial, organizational or managerial, knowledge or human, and Environmental or social.

The findings from this study also align with the Technology–Organization–Environment (TOE) framework frequently used in studies about adopting innovations. This framework indicates that a company's choice to implement a new technology depends on three connected areas: technology, organization, and environment. The technology aspect covers the characteristics of the new technology itself, like how complex it is, how well it fits with existing systems, and what advantages it offers, all of which can impact decisions about whether to adopt it. The organizational aspect focuses on internal elements such as the company's size, structure, resources, and support from management, which can either encourage or discourage adoption. Meanwhile, the environmental aspect includes outside influences like market trends, competition, regulations, and institutional support, all of which can create opportunities and barriers for adopting innovations. To overcome these problems and speed up integration, this study suggests the following key strategies; Developing well-defined national policy and standards to facilitate the implementation of automated systems and robotics, Introducing specialized educational programs for professionals and students to improves skills and training, financial assistance in form of funding, loans, and tax reductions to encourage investment in automated technologies, and Promoting collaboration between the public and private sectors; i.e. government, educational institutions, and businesses to improve innovation and the spread of technology.

6. Limitations and Future Directions

Despite the contribution of this study and its ability to serve as a useful reference point for both researchers and decision-makers exploring construction innovation. A few limitations were acknowledged, which can serve as a foundation for future researchers and studies to build upon. The findings from this study are limited to a single academic source, and no model was proposed for the adoption of innovations such as automation and robotics. future studies should therefore focus on creating automated technology models that can be adapted to local conditions, specifically tailored to the environmental, economic, and practical realities of less developed nations. This strategy will help close the technology gap and support sustainable growth within the global construction industry. A study on the ranking of the barriers and the model of their relationship should also be considered as future research directions.

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