Understanding Lean Construction Practices: A Scopus-based Bibliometric Study

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Abstract

It is commonly known that the lean construction philosophy improves efficiency, reduces waste, and enhances sustainability in the construction industry. However, despite its growing relevance, the structure of research around lean construction is still fragmented. This paper maps their research spectrum and identifies relevant and current themes within the field of lean construction through a bibliometric analysis by analyzing the last five years of Scopus-indexed publications and conducting a keyword co-occurrence investigation

The network visualization extracted from VOSviewer indicated 5 major clusters highlighting obstacles to lean adoption - digital integration through building information modeling and life cycle approaches - project level applications - collaboration and organizational practices - and integration of lean principles with off-site construction.

The results provide a structured overview of lean construction research, highlighting the areas that researchers and scholars have focused on over the last five years. The study contributes to understanding the research landscape of lean construction for both academics and practitioners.

Keywords

Lean Construction, Bibliometric Analysis, Keyword Co-Occurrence, Scopus, VOSviewer.

1. Introduction

Adopting Lean Construction practices in construction projects is essential for successful project outcomes. This philosophy entails optimizing processes to maximize value while minimizing resources. Several benefits and considerations of Lean Construction involve cost/duration reduction (Muñoz Pérez et al., 2023), improved productivity (Garcés & Peña, 2023), enhanced communication (Elmalky et al., 2024), and proactive collaboration (Nithyanandan S & Sindhu Vaardini U, 2023).

The global adoption of Lean practices is increasingly evident in both academia and industry. As far as Lean practices in Academia are concerned, Garry (2020) highlighted how reduced funding and heightened competition motivated the adoption of Lean Management techniques in universities. For example, the Kaizen event at South Dakota University illustrates how Lean tools can streamline operations and enhance student experiences (Garry, 2020). Furthermore, Lean adoption involves multiple global trends, ranging from interdisciplinary growth (operations, organizational behavior, and strategic management), specifically in emerging economies (Sinha & Matharu, 2019), to a sustainability focus on contemporary organizational strategies (Amaro et al., 2019).

While Lean Construction has been widely researched, there is a lack of clarity about the scope of research themes and practices in recent years. Therefore, due to the fragmented research, there is a need to consolidate major keywords and themes to understand the “big picture”. Thus, the objective of this paper is to underscore the knowledge base and reveal research clusters, trends, and gaps in Lean Construction research, using Scopus database and VOSviewer to conduct our bibliometric analysis.

2. Methodology

In order to meet the objective of this paper, we conducted a bibliometric analysis to map the research trends of Lean Construction within the research spectrum. To do so, we selected Scopus as our database for its breadth and reliability. Moreover, we solely searched for the keyword "Lean Construction" and focused on articles, conference papers, reviews, and book chapters. Additionally, we selected documents published from 2020 to August 20th, 2025 (when the bibliometric analysis was conducted). As a result, we extracted a total of 1084 Scopus-indexed documents (initial pool being 2530) and injected them into VOSviewer for the co-occurrence analysis. Finally, we applied a co-occurrence threshold of 33 repetitions per keyword and manually eliminated 3 repeated keywords out of 40 that were extracted by the software. Last, but not least, a manual and thorough analysis of the clusters and keywords showcased in the network visualization (See Fig. 1) was conducted and is presented in the following section of this paper.

3. Results and Discussion

3. 1 Network Visualization

The figure below represents the network visualization extracted from VOSviewer. We can easily distinguish 5 clusters (Red, Green, Blue, Yellow, and Purple). Each cluster has its own relevant keywords, subjects, and themes that we will discuss in the following subsection.

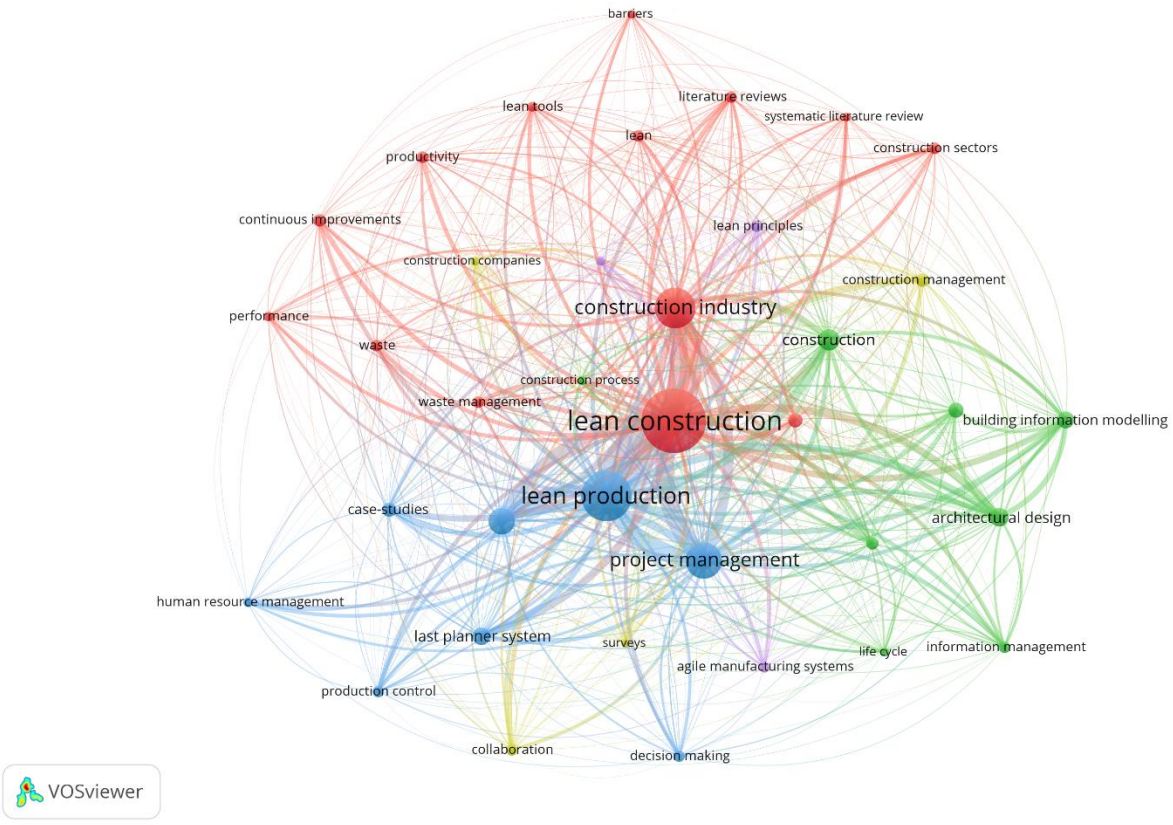

Fig. 1. Network Visualization of the bibliometric analysis of Lean Construction using VOSviewer.

3. 2 Interpretation of Results

The first cluster (Red) discusses the obstacles to Lean Construction implementation with an emphasis on performance improvement and sustainability. For instance, keywords like barriers, construction industry, construction sectors, and

literature review entail that research investigates the enablers and barriers of lean construction adoption. Additionally, lean tools, continuous improvement, productivity, and performance represent the central thread in how Lean techniques promote several key project outcomes in the construction industry. Moreover, the terms waste and waste management highlight a pillar of the lean philosophy. Finally, the mention of systematic literature review and literature review indicates the research and study type conducted to synthesize knowledge about lean implementation.

The second cluster (Green) represents the integration of digital technologies, design processes, and sustainability. To illustrate this, keywords like BIM, building information modeling, information management, and construction processes showcase the role of technologies in enabling lean practices. In addition to that, architectural design and lifecycles point to how Lean thinking is applied in the entire project life cycle, from early design to operation, with a strong focus on sustainable development and information management.

The third cluster (Blue) centers on project-level lean applications and management practices. For example, terms such as case studies, construction projects, and project management highlight that the research contributions extracted from Scopus are empirical and practical. In addition to that, the focus on planning and efficiency is noticed through terms like last planner system (LPS), lean production, and production control. Furthermore, the role of people and leadership in ensuring lean implementation success is underscored through terms like decision-making and human resource management.

The fourth cluster (Yellow) emphasizes collaboration and organizational practices in lean construction. As a matter of fact, keywords such as collaboration, construction companies, and construction management highlight the need for a better organizational culture and proactive collaborative approaches for lean management to succeed. Also, the term survey suggests that the research focuses on understanding organizational practices and stakeholder attitudes via empirical data collection.

Last but not least, the fifth cluster (Purple) captures the innovative production systems and industrialized construction methods. For instance, keywords like agile manufacturing system, lean principles, and off-site construction show how lean practices intersect with agile approaches.

3.3 Insight from literature

Cluster 1:

Several barriers and enablers influence the adoption of lean practices, specifically in the context of performance and sustainability. We aim to outline the key barriers and enablers identified in the literature.

Several barriers hinder the smooth adoption of Lean practices. To start with, according to Moradi & Sormunen (2023) multiple organizations lack awareness and a fundamental understanding of lean principles, which complicates further implementation. In addition, Moradi & Sormunen (2023) suggested that cultural inertia and employee resistance can significantly block lean adoption. Moreover, Bayhan et al. (2019) and Kaswan et al. (2023)focused on the role of top management, since it impacts commitment and resource allocation. Finally, Alayón et al. (2022) highlighted how financial constraints can restrict necessary training for lean implementation.

Now that we have an idea of the barriers to lean adoption, it is equally important to explore the enablers. First, Bayhan et al. (2019) and Moradi & Sormunen (2023) agreed on the importance of fostering a lean practice culture through strong commitment from leadership. Second, it is also essential to mitigate resistance among employees by providing adequate training to help the team understand and apply lean practices effectively (Alayón et al., 2022). The goal of this training is to cultivate a culture within the organization that embraces the pillars of lean philosophy (Moradi & Sormunen, 2023). Finally, clear and effective communication should remain the essence of lean transformation (Bayhan et al., 2019).

Cluster 2:

The second cluster dives into three essential components of lean construction. In fact, digitalization, design, and sustainability represent a transformative journey toward efficiency and operational excellence.

To start with, it is essential to acknowledge how the technological integration of digital tools, such as Building Information Modeling (BIM), greatly facilitates data management and proactive communication (Fonseca et al., 2024). Additionally, lean practices align perfectly with sustainability goals as far as responsible consumption and production are concerned (Wibowo & Ammar, 2025). Moreover, the implementation of lean tools, specifically during the design phase of projects, helps improve cost, schedule, and quality, particularly LEED-certified ones (Moustafa Hussien & Iraqi, 2022).

To sum up, it is clear how tight lean construction and digitalization drive sustainability, as indicated by the circular construction approach (Koskela, 2023). Therefore, it is crucial to embrace long-term resilience in a quickly changing environment directed by digital technologies and sustainable ambitions (Prasadinee et al., 2024).

Cluster 3:
The third cluster in our network visualization map dives into project-level lean applications. These latter benefits from integrating human factors, which enhance operational performance and employee well-being.

For example, according to Chrusciak et al. (2023), applying lean principles in healthcare improves the way materials are handled. Also, it is important to underline the interplay between technical regulations of the public sector and human behavior (Estrada Herrera & Pueblita Mares, 2023). Furthermore, Gaiardelli et al. (2019) highlighted the influence of technical and people-oriented lean practices on employee behavior and job characteristics. Additional research highlighted multiple aspects of human factors in lean application, for instance, ergonomics (Naranjo-Flores & Ramírez-Cárdenas, 2014) and cultural change (Rodrigues & Steffen, 2022).

Another major aspect of project-level lean construction applications involves tailored strategies to address the diverse needs of all the stakeholders, since they heavily impact lean implementation (Prabaharan et al., 2024) and the mandatory need for a supportive environment (Hyarat et al., 2024).

Cluster 4:
Another major aspect of lean construction is collaboration and organizational practices that enhance knowledge creation and efficiency in the construction industry. In the following section, we will explore the literature related to the fourth cluster in our bibliometric analysis.

The first aspect we need to underline is knowledge creation. In fact, Trentin & Etges (2021) showed that various tools and training methods are required to generate knowledge. Additionally, they added that lean construction principles make the generation easier, thus improving overall project outcomes (Trentin & Etges, 2021).

Another aspect related to collaboration in lean construction settings is the organizational structure. Howell (2013) insisted on switching gears from command and control to collaborative frameworks for effective lean adoption because companies face various challenges when adapting their organizational structure to implement lean construction (Alarcón & Diethelm, 2002).

The last aspect in the fourth cluster is social dynamics. To start with, social network analysis (SNA) assesses collaboration and communication through the identification of strengths and weaknesses within organizations (Herrera & Alarcón, 2022). Furthermore, (Herrera & Alarcón, 2022) highlighted the critical components (trust, open communication, and commitment) to optimal lean construction implementation.

Cluster 5:
The fifth cluster in our network visualization map focuses on innovative production systems and industrialized approaches in the construction industry. In the following section, we will discuss key aspects of these innovative approaches.

To start with, off-site construction methods (e.g., prefabrication) allow better manufacturing of components, especially in controlled environments, which reduces waste and improves quality (Pozzi et al., 2023). These techniques have surged and shown a great acceptance rate among multiple countries around the world, such as Malaysia (Al-Aidrous et al., 2021).

Additionally, other techniques, such as 3D printing and robotic process automation, significantly enhance labor efficiency and sustainability. Therefore, they support how to streamline processes and standardize industrialized construction (Vásquez-Hernández et al., 2022).

3.4 Summary
The table below (Table 1) summarizes the major themes highlighted in the network visualization extracted for the bibliometric analysis software.

Table 1. Summary of the co-occurrence keyword analysis

Cluster	Main Theme	Sub-Themes
Red	Barriers and enablers of lean adoption with a focus on performance and sustainability	Barriers to Lean adoption; Productivity and Performance; Waste reduction and sustainability; Systematic reviews;
Green	Digitalization, design, and sustainability in lean construction	BIM as a Lean driver; Information Management; Lifecycle-based approaches; Sustainable design;

Blue	Project-level lean applications and human factors	Lean Methods in projects; LPS and production control; Decision-making; Human resource management;
Yellow	Collaboration and organizational practices in lean construction	collaboration across stakeholders; Company-level adoption; Management strategies; Survey-based Lean maturity
Purple	Innovative production systems and industrialized approaches	Lean-agile integration; Off-site/prefabricated construction; Innovative production method;

4. Conclusions

This paper explored the scope of lean construction research in the last five years using the Scopus database and the bibliometric analysis technique. The investigation identified 5 research trends: obstacles and performance in lean adoption, digital integration through BIM and lifecycle approaches, project-level applications and human factors, collaboration and organization practices, and emerging approaches combining lean practices with agile and off-site construction.

The findings of this study contribute to mapping the research spectrum of lean construction in the last five years. This will provide researchers with a structured overview of recent developments so that they can shape the trends around the management of construction projects.

In this study, we solely relied on a single database and keyword-based analysis, which may not capture all the nuances around the lean construction practices research spectrum. Future work could expand to multiple databases or apply other analyses, like the overlay visualization map that tracks research evolution over time.

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