CAN BUSINESS MODELS MINIMISE LEAN IMPLEMENTATION BARRIERS IN CONSTRUCTION INDUSTRY? A SYSTEMATIC LITERATURE REVIEW

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Abstract: Lean construction (LC) is a strategic concept for eliminating non-value-added activities and striving to increase value delivery in the construction industry. However, various barriers hinder its widespread adoption. To overcome these obstacles, Business Models (BMs) could offer a potential solution to facilitate and enhance the integration of lean principles in the sector. However, there are lack of a study examining how the integration of BMs can minimise the barriers to lean implementation. Therefore, this paper reviews whether can lean construction implementation barriers be minimised through business models in the construction industry. This aim was achieved through a systematic literature review (SLR). An SLR was conducted to identify key themes, trends, and gaps in the existing research. The findings reveal a growing interest in LC and BMs, with a significant increase in publications since the early 2000. The analysis identifies leading countries, research areas, and key keywords in the field. BM publications are concentrated in the United States, China, and Europe, while LC research is more globally distributed. The keyword "barrier" is most prominent, followed by "lean implementation" and "performance" in "lean construction" research. The central theme of the "business model" connects to concepts like "lean start-up" and "lean management", highlighting the integration of lean principles focused on efficiency and waste reduction. Overall, the research provides valuable insights into the interplay between LC and BMs, offering guidance for researchers and practitioners striving to increase value delivery in the construction industry.

Keywords: *Business Models (BMs), Construction Industry, Lean Construction (LC), Systematic Literature Review (SLR)*

1. Introduction

Despite the construction industry's vast contribution to global economic development, the industry faces persistent challenges that hinder its performance and efficiency (Chen et al., 2022; Dauda et al., 2023). Challenges such as time and cost overruns, material shortages, low productivity, poor safety standards, and resistance to change are well-documented across various studies (Chen et al., 2022; Das et al., 2022; De Wolf et al., 2023). These challenges are exacerbated by the industry's fragmented and multi-disciplinary nature, making it difficult to meet client expectations and deliver projects within budget and on time (Bajjou & Chafi, 2018; Mokhtariani et al., 2017). To address these issues, construction organisations increasingly turn to innovative approaches such as Lean Construction, which aims to minimise waste or non-value-adding activities and optimise value in construction processes.

Lean Thinking, originating from the Toyota Production System (TPS) developed in the 1940s under Taiichi Ohno, laid the foundation for systematic waste reduction and value optimisation in production processes (Osunsanmi et al., 2019; Victor, 2023). Initially focused on car engine manufacturing, TPS expanded its influence on vehicle assembly and supply chain management, introducing lean principles that emphasised people and continuous improvement (Abbadi et al., 2020; Melton, 2005). These principles were later adapted to the construction industry, with Koskela's 1992 research establishing the theoretical basis for Lean Construction (LC), which identified benefits such as improved quality, cost control, and safety (Koskela, 1992).

From the late 1990s to the early 2000s, lean principles were practically adapted to the construction sector, highlighting the need for appropriate tools, validated theories, and contextual application of LC principles (Ballard, 1993; Santos, 1999; Howell & Koskela, 2000). In recent years, the evolution of LC has focused on collaboration, continuous improvement, and the integration of digital technologies, further embedding LC into modern construction management practices (Babalola et al., 2019b; Hamzeh et al., 2021).

The implementation of LC offers numerous benefits to construction projects, including time and cost reduction, increased labour productivity, enhanced process efficiency, improved client satisfaction, reduced waste, better construction quality, higher market share, stakeholder satisfaction, standardised processes, and reduced environmental impact (Ahiakwo et al., 2013; Ahmed et al., 2020; Babaremu et al., 2022).

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Despite the potential benefits of LC, its implementation is often constrained by a range of barriers. These barriers, which include management, financial, educational, technical, and human attitudinal issues, complicate the adoption of lean construction practices and limit their effectiveness (Musa et al., 2023; Bashir et al., 2015). Key barriers include a lack of awareness and understanding of lean concepts, tools, and techniques, time and commercial pressures, cultural resistance, lack of top management commitment, the disconnect between design and construction, the absence of process-based performance measurement systems, insufficient standardisation, and an unstable political environment (Ahmed et al., 2020; Ali, 2002; Asadian et al., 2021; Babaremu et al., 2022; Evans & Farrell, 2020; Feldmann, 2022; Razabillah et al., 2023). A systematic understanding of these barriers is crucial for developing strategies that can enhance the adoption of lean concepts in the construction industry. However, the lean concept has alarmed construction organisations to rethink their processes to reduce the cumbersome barriers (Ahmed et al., 2020a) and understand the 'value' of construction projects to optimise the return on investment to the organisation and their stakeholders (Babaremu et al., 2022; Ranadewa et al., 2021).

Generally, construction businesses are more risky in nature than other industrial businesses, due to challenges such as economic uncertainties, competitive market conditions and actions of the regulatory bodies (Antunes & Gonzalez, 2015). Hence, construction organisations are required to develop solutions for increasing the productivity of the business, and satisfying the requirements of the customers while focussing on the long-term business perspective and sustainability (Kujala et al., 2010).

To navigate the uncertainties and challenges of the construction industry, companies have increasingly adopted Business Models (BMs) as strategic tools for optimising value, enhancing customer satisfaction, and ensuring long-term sustainability (Abeynayake et al., 2022; Arend, 2013). Osterwalder et al. (2005) defined a BM as the rationale for how an organisation creates, delivers, and captures value, while Kindstrom and Kowalkowski (2014) described it as a tool for visualising the internal changes needed to maintain transparency and optimise service potential. BMs provide insights into business operations, enabling organisations to develop competitive strategies, create high customer value, and address stakeholder conflicts. Furthermore, BMs offer a structured framework for facilitating the implementation of LC by aligning organisational processes, resource allocation, and value creation with LC principles, thereby enabling more effective interventions (Das et al., 2023). BMs not only help construction companies tailor competitive products to specific customer segments but also investigate and resolve conflicts of interest among key stakeholders (Verstraete et al., 2017).

Recent studies have suggested that the successful implementation of LC can be better understood and facilitated through the lens of BMs. Business models provide a structured approach to examining how various factors, such as organisational structure, resource allocation, and value creation processes, interact with and impact the adoption of LC (Cano et al., 2015; Enshassi et al., 2021). By analysing LC implementation barriers through business models, it is possible to identify specific areas where interventions can be most effective.

This paper therefore aims to explore the relationship between LC implementation barriers and BMs using a systematic literature review (SLR). By systematically reviewing and analysing the existing literature, this study seeks to identify key themes, trends, and gaps in the research. This paper starts with the introduction, followed by materials and methods used for the literature review. The next section presents the results of the systematic literature review. The paper finally presents conclusions and a way forward.

2. Material and Methods

This research employs a systematic review of the literature to evaluate the current state of research on both lean concept and business model implementation in the construction industry.

To investigate the implementation of lean principles within the construction industry, a comprehensive search was conducted across several databases, including Scopus, and Taylor & Francis. The initial search, using the terms "Lean" AND "Construction Industry" OR "Construction Project" OR "Construction Organization" OR "Construction Organisation" OR "Construction Firm" OR "Construction Consultant" OR "Infrastructure" OR "Building Project" OR "MEP" OR "Mechanical" OR "Electrical" OR "Plumbing" OR "Contractor" OR "Sub-contractor" OR "Construction Material Supplier" OR "Renovation Projects" OR "Construction Renovation", retrieved 7,370 documents. To refine the results, the search was narrowed to focus specifically on Article Titles, Abstracts, and Keywords, reducing the number of relevant publications from 7,370 to 591 by excluding documents that did not directly address the core themes of lean implementation in the construction industry. Further refinement involved filtering out duplicates, theses, lecture notes, and irrelevant studies, leading to 511 unique publications. These were then analysed through a SLR to ensure they directly addressed the implementation of lean principles in the construction industry.

In addition, a focused search was carried out to explore the implementation of BMs within the construction industry using Scopus and Taylor & Francis. The initial search, using the terms "Business Model" AND "Construction Industry" OR "Construction Project" OR "Construction Organization" OR "Construction Organisation" OR "Construction Firm" OR "Infrastructure" OR "Building Project" OR "Contractor" OR "Sub-contractor" OR "Construction Material Supplier", retrieved

4,330 documents. To refine the results, the search was narrowed to focus specifically on Article Titles, Abstracts, and Keywords, reducing the number of relevant publications from 4,330 to 101 by excluding documents that did not directly address the core themes of lean implementation in the construction industry. Further refinement involved filtering out duplicates, theses, lecture notes, and irrelevant studies, leading to 97 unique publications. The results of this review are also discussed in the following sections.

3. Results of Systematic Literature Review

As the first step of the analysis, a statistical examination is performed to assess publication trends across two dimensions: publication year and country of origin.

3.1. MAPPING OF RESEARCH WITH PUBLICATION YEARS

Based on the search results, the publications are distributed across different years. Therefore, the following graphs represent the distribution of research publications over time. Figure 1 presents the number of publications analysis on trends in lean implementation in the construction industry and Figure 2 depicts the number of publications analysis on trends in BM implementation in the construction industry, over time.

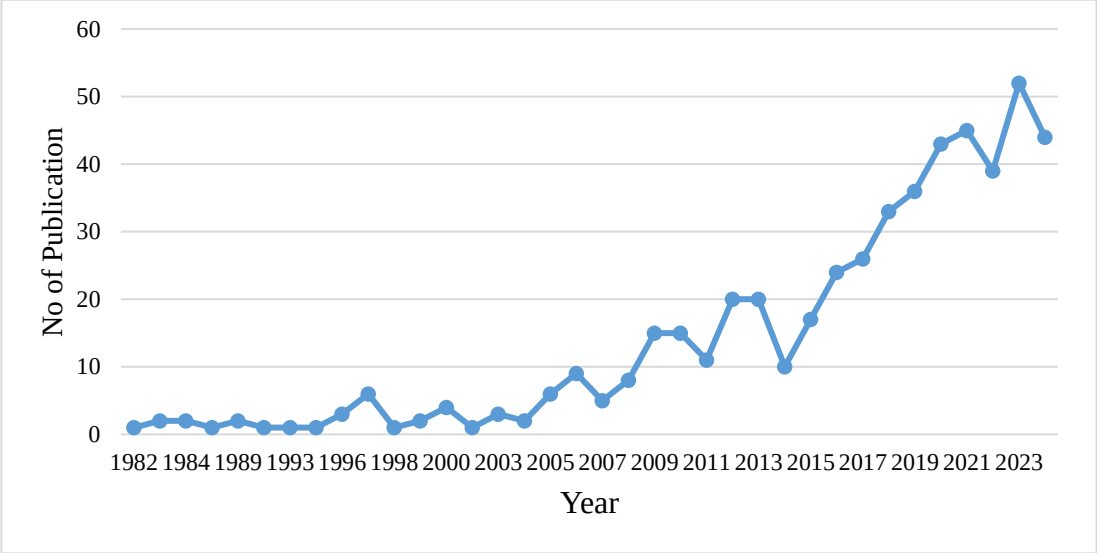

Figure 1: Number of Publications Over Time: Trends in Lean Implementation in the Construction Industry

Figure 1 illustrates the yearly trend of publication across various databases over 24 years, from 1982 to 2024. The y-axis indicates the number of publications, while the x-axis denotes the year of publication. The early years, from 1982 to 2008, show minimal activity, with only a few publications each year. A noticeable increase began in 2009, with a significant rise in publications from 2014 onward. The most substantial increase occurs from 2018 to 2024, with the highest number of publications in 2023. This study was carried out in mid-2024 and hence, year 2024 information is not available.

This growth trend peaked in 2023, reaching approximately 50 publications, indicating heightened research interest and activity in this area. The overall trend suggests a sustained and growing academic focus on lean implementation in the construction industry, reflecting the increasing recognition of its importance in addressing industry challenges. This analysis indicates that LC has become a significant research topic, particularly in the last decade, as the industry seeks to optimise processes and reduce waste.

Figure 2 illustrates the trend in the number of publications related to the implementation of BMs within the construction industry from 2000 to 2024. The data shows a gradual increase in research activity over the years, with some fluctuations. Initially, from 2000 to 2013, the number of publications remained relatively low and steady, with occasional minor spikes. However, a notable increase in research interest is observed starting from 2014, with a significant upward trend, particularly from 2018 onwards. This growth trend peaked in 2023, reaching approximately 12 publications, indicating heightened research interest and activity in this area. The overall trend suggests a sustained and growing academic focus on BM implementation in the construction industry, reflecting the increasing recognition of its importance in addressing industry challenges.

The trends in research publications highlight the evolving interest in LC and BMs within the construction industry, as revealed through an SLR. Since the early 2000s, there has been a notable increase in publications on both topics, signalling growing research activity and recognition of their importance. Notably, the steady and pronounced rise in publications related to lean implementation, particularly between 2010 and 2024, underscores the sustained focus on integrating lean

principles into construction practices. This contrasts with the more fluctuating trend observed in publications on BMs, which, despite showing overall growth, exhibit less consistency, with significant peaks in 2012 and 2023. The data suggests that while there is considerable interest in both areas, lean implementation has garnered more consistent and dominant attention, potentially indicating its perceived value in addressing barriers in the construction industry through the application of lean principles. This analysis highlights the critical role that lean implementation plays in shaping BMs and overcoming industry challenges.

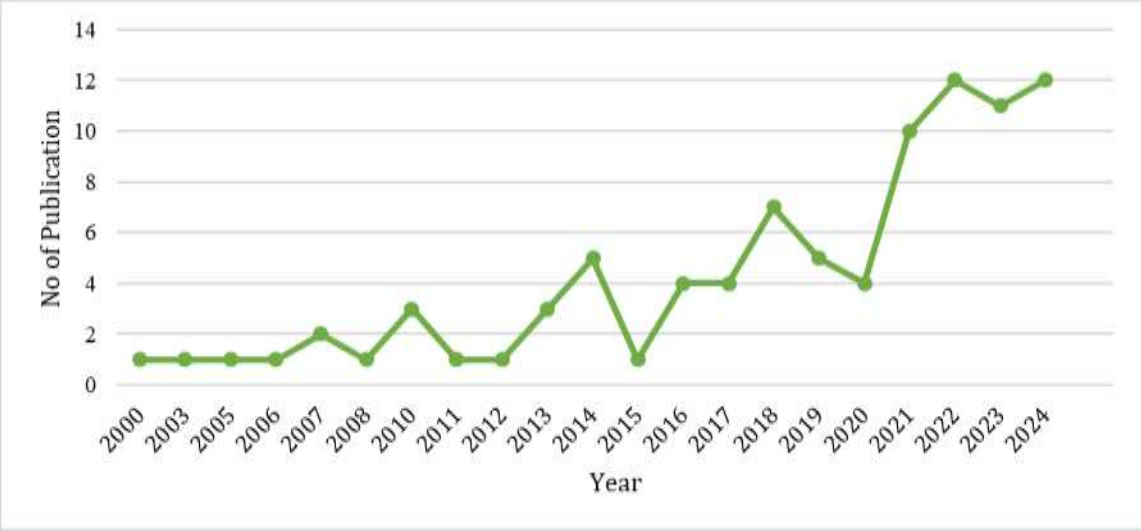

Figure 2: Number of Publications Over Time: Trends in Business Model Implementation in the Construction Industry

3.2. MAPPING OF RESEARCH AREAS/KEYWORDS AND COUNTRIES

Based on the search results, the following maps illustrate the distribution of publications across various countries. Figures 3 and 4 present the distribution of publications on lean implementation and business models in the construction industry across the countries, respectively.

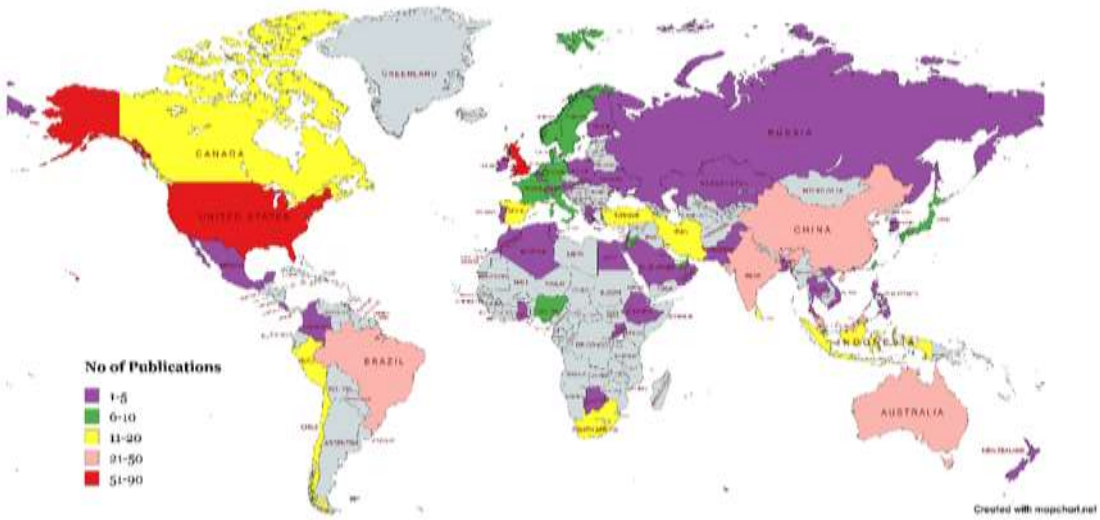

Figure 3: The Worldwide Spatial Distribution of Publications on Lean Implementation in the Construction Industry

The distribution of publications on lean implementation in the construction industry across 68 countries highlights significant disparities in research activity within the field as shown in Figure 3. The United States and the United Kingdom lead with 51 - 90 publications, indicating a strong and sustained research focus. Other major contributors include India, China, Brazil, Australia and Malaysia, each falling within the 21 - 50 publication range. This indicates substantial academic interest and research output in these countries. Countries such as Turkey, Indonesia, Peru, Sri Lanka, Chile, Iran, South Africa, Spain and Canada, with 11 - 20 publications each, demonstrate a moderate but notable engagement in the research area. The 6 to 10 publication range includes several countries, such as the Netherlands, Sweden, Denmark, Germany, Norway, France, Nigeria, Taiwan, United Arab Emirates, Italy, Japan, Jordan, and Singapore. Around 39 countries fall within the 1 - 5 publication range. Overall, the data reveals a globally distributed research effort, with leading contributions from both developed and developing nations.

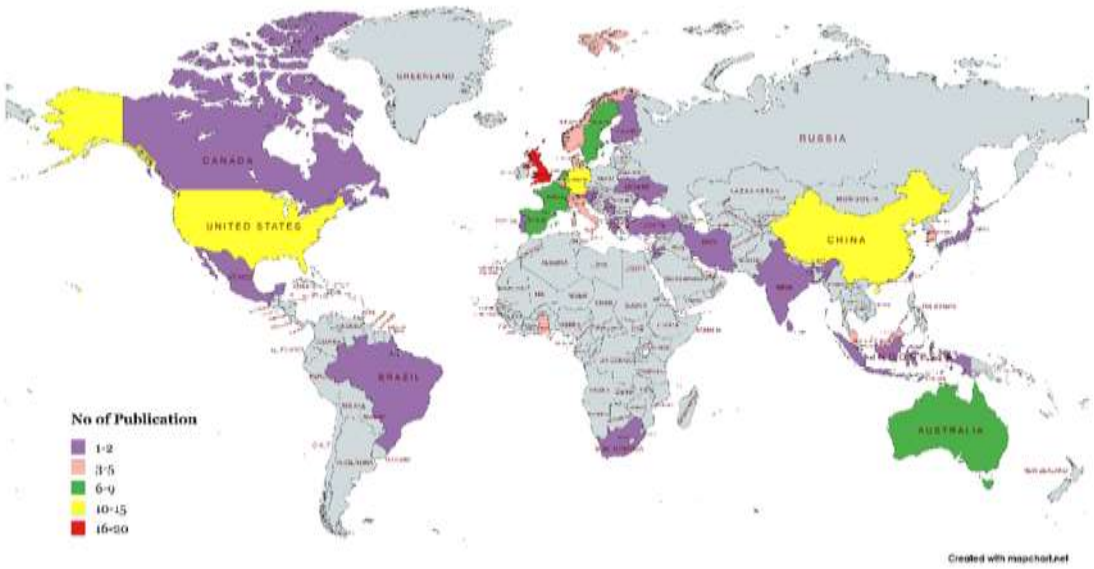

Figure 4: The Worldwide Spatial Distribution of Publications on Business Model Implementation in the Construction Industry

In Figure 4, the distribution of publications across 37 countries highlights significant disparities in research activity within the field of BMs. The United Kingdom leads with 16 - 20 publications, demonstrating a strong research output. Other prominent contributors like the. The United States, China and Germany are in the 10 - 15 range, showcasing their significant involvement in global research. Countries such as the Netherlands, France, Australia, Spain, and Sweden fall within the mid-range, contributing 6 - 9 publications in BMs. Several countries, including Belgium, Ghana, Malaysia, Norway, South Korea and Switzerland, contribute a moderate number of publications (3 - 5), indicating active but less extensive research efforts. A large number of countries fall in the lowest category, with 1 - 2 publications.

The comparative analysis of the global distribution of research publications related to the construction industry, focusing on BMs and the implementation of lean concepts, reveals distinct regional patterns and research priorities. The concentration of publications on BMs in North American and European regions is noticeable, with the significant number of publications highlighting the strong research presence in these areas. From the Asian region, most of the countries in the East Asian region provide major contributions to global research with a significant number of publications. In the other regions, such as South American, African, and Oceanian, the overall activity is relatively lower compared to the aforementioned regions. However, all these regions have shown that there is considerable interest in the research area of BM in the construction context. In the context of lean implementation in the construction industry, the North American region dominates with a high number of publications, and a significant number of countries in Europe demonstrate an output of the publication. However, the countries in the Asian region have also shown considerable interest in the research area of lean implementation in the construction industry. Meanwhile, other regions, such as Australian, South American, and African, show a moderate level of publications, pointing to a developing research ecosystem in these countries. However, all these regions have shown that there is considerable interest in the research area of lean implementation in the construction context.

3.3. NETWORK MAPPING OF RESEARCH KEYWORDS: LC AND BM

The network mapping of the research area was developed using VOS viewer, focusing on the keywords relevant to this study, i.e., LC and BMs. A thorough cleaning process was conducted to remove duplicates in keywords related to LC and BMs, ensuring the accuracy of the final output, which are presented in Figures 5 and 6 respectively.

Figure 5 presents the most popular keywords found in the selected research articles. This analysis highlights the current research trend towards the implementation of lean principles in the construction industry, as illustrated by the published keywords. The size of the nodes in the figure indicates the frequency of keyword usage, while the links between them represent the correlation between these keywords. The largest node represents “barrier”, highlighting it as the most commonly used keyword in the dataset which signifies obstacles to successful lean construction implementation. The network diagram displays clusters of related terms groped by colours, each representing different aspects of lean construction. As an example “lean tools” in green colour node linked to terms such as "effectiveness" and "quality," while "value" and "time" in blue relate nodes to “cost” and “lean techniques”. However, The involved connections suggest a high degree of interdependence among these factors, with barriers acting as a significant influence on the overall implementation process, impacting productivity, value, and quality. In addition, the keywords such as "critical success factor" and "construction waste" indicate additional considerations for successful lean implementation. Furthermore, following this, keywords such as “lean implementation”, “lean construction implementation”, “performance”, “lean principles”, and “lean

practices" were also leading, reflecting their popularity and demand in the field. Overall this diagram highlights that overcoming barriers requires a comprehensive understanding of these interconnected factors within lean construction.

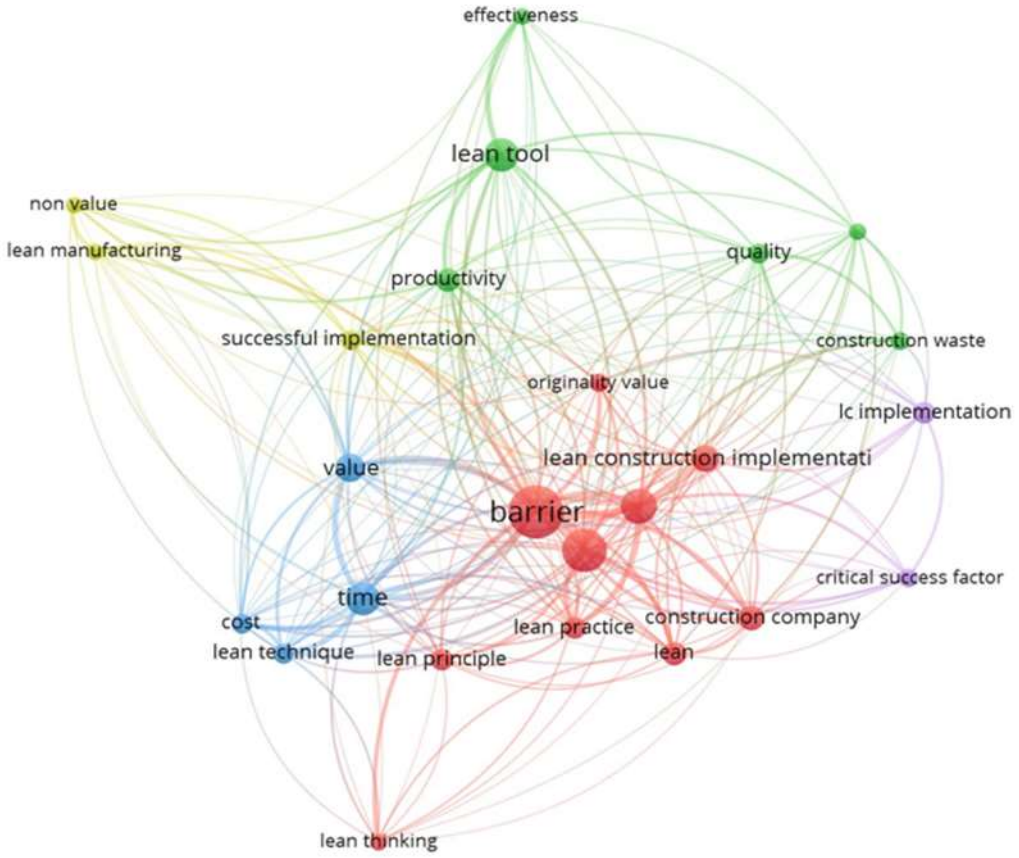

Figure 5: Network Visualisation of Keywords Related to Lean Construction Implementation

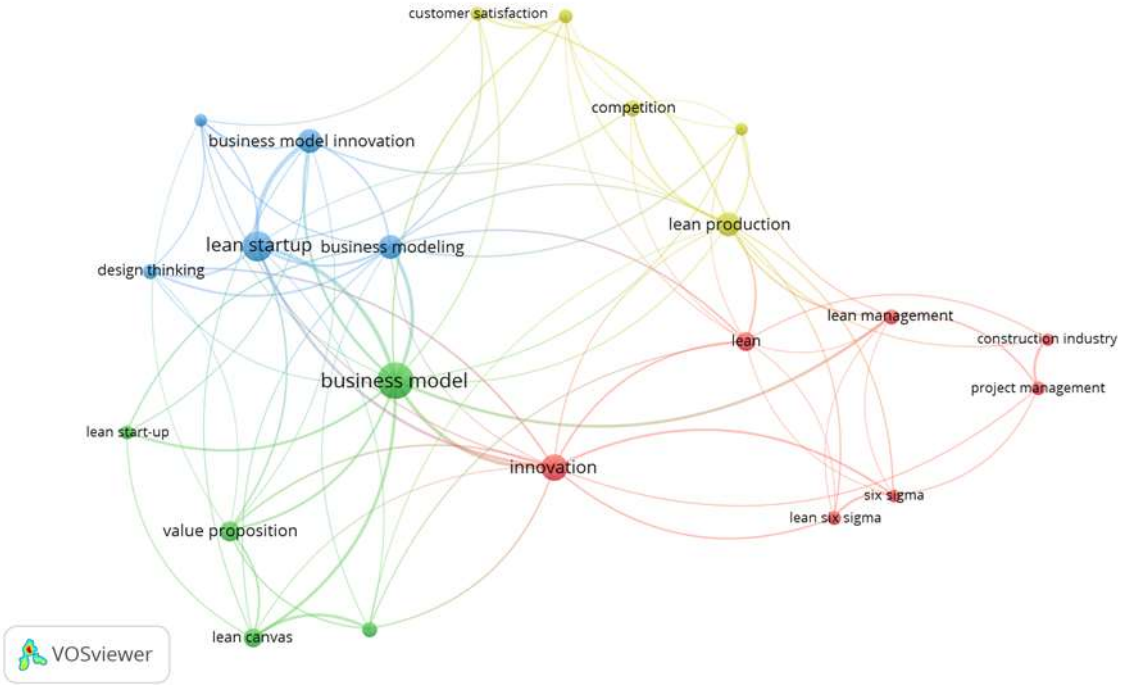

Figure 6: Network Visualisation of Keywords Related to Business Model Implementation

The above VOSviewer map in Figure 6 provides a visual representation of the interconnected terms related to BM implementation within the construction industry. At the core of the map, the central node "business model" connects to a network of concepts that shape its development and implementation. Key themes include the integration of lean principles,

such as “lean start-up”, “lean production”, and “lean management”, which emphasise efficiency and waste reduction. The prominence of “innovation” in the map highlights its pivotal role in BM development, with related terms such as “design thinking” and “value proposition” underscoring the importance of customer-centricity and value creation. The network map also reveals the use of structured frameworks and methodologies, evidenced by terms like “lean canvas” and “business model modelling”, which are essential tools for crafting and analysing business models. Additionally, the inclusion of industry-specific terms such as “construction industry” and “project management” indicates the unique context in which these innovations are applied. Overall, the network map illustrates the intricate interplay of factors that influence business model innovation in the construction sector, offering insights that can help researchers and practitioners develop more effective and sustainable strategies to address the industry's challenges and opportunities.

Overall, the above network maps visually depict the intricate relationships between LC and BMs within the construction industry, offering valuable insights through a bibliometric analysis. While there are overlapping themes, each map emphasises different aspects of these interconnected fields. The first network diagram is centred on the factors crucial to the successful implementation of LC, highlighting lean principles, tools, and critical success factors such as quality, productivity, and value. This map presents a more linear and hierarchical structure, indicating a step-by-step approach to overcoming barriers in lean implementation. In contrast, the second network diagram delves into the elements of BMs, underscoring the importance of lean principles, innovation, design thinking, and value proposition in creating effective BMs. This network diagram exhibits a more complex and interconnected network, reflecting the multifaceted nature of innovating BMs in the construction industry. Together, these networks offer complementary perspectives that enhance our understanding of how lean implementation and business model innovation can be integrated to address barriers in construction management. By exploring these relationships, researchers and practitioners can devise more holistic strategies to improve efficiency, productivity, and sustainability in the industry.

4. Conclusions

This SLR offers a detailed overview of the current research landscape on lean implementation and business models in the construction industry. The findings reveal a significant increase in research activity on both topics, particularly in recent years, highlighting their growing importance in addressing industry challenges. Research on BMs is notably regionally concentrated, while LC has a broader international reach, indicating a global trend towards their adoption. The analysis demonstrates the interconnectedness between LC and BM integration, emphasising their combined potential to enhance efficiency, productivity, and sustainability within the sector.

However, this SLR reveals a significant increase in research activity on both LC and BMs over recent years. Lean construction has seen a particularly marked rise in publication volume since 2014, reflecting a growing recognition of its potential to address critical issues such as inefficiency, value optimisation, waste minimisation and poor safety standards in the construction industry. Similarly, research on BMs has experienced a noticeable growth, particularly from 2018 onward, indicating a rising interest in understanding how BMs can optimise value creation and sustain long-term success in the sector.

Furthermore, the geographical distribution of research shows diverse global engagement, with India and Brazil leading in LC research, and the United Kingdom, the United States, and China prominent in BM studies. Network mapping of research keywords illustrates the primary areas of interest within each domain. For LC, keywords like “barrier”, “lean implementation”, and “performance” dominate, emphasising the sector’s focus on overcoming implementation challenges and enhancing operational efficiency. In contrast, BMs research emphasises themes of “business model” connected to concepts like “lean start-up” and “lean management”, reflecting the industry’s interest in developing innovative and customer-centric business strategies.

Despite these advancements, barriers such as management, financial, technical, and cultural challenges remain, necessitating a deeper understanding of how LC and BMs intersect with each other. Future research should aim at empirical studies on the integration of LC with BMs, explore regional research variations, and develop integrated frameworks that combine LC and BM concepts. Overall, this study underscores the critical role of understanding the relationship between LC and BMs in improving construction industry efficiency, project outcomes, and long-term sustainability, providing valuable insights for researchers and practitioners seeking to advance the field and address industry barriers.

5. Way Forward

This study will further delve into the specific mechanisms by which lean implementation can optimise through business model innovation, and vice versa. Moreover, empirical studies are essential to validate the insights from this SLR and to offer practical guidance for professionals in the construction industry.

Based on the findings from this SLR, the next steps of this study involve assessing how BM can be used to effectively integrate LC concepts. This approach aims to reduce waste and increase value in the construction industry. The way forward

includes developing a comprehensive framework that aligns LC principles with BM strategies. This will involve analysing various BMs to identify best practices for integrating lean methodologies, conducting pilot studies to test these integrations in real-world settings, and refining the framework based on feedback and outcomes. Additionally, collaboration with industry experts and stakeholders will be crucial to ensure that the developed framework addresses practical challenges and provides actionable solutions. Through these steps, the goal is to enhance the implementation of the LC concept in BMs, ultimately driving efficiency and innovation in the construction sector.

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