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Integrated Scientometric Analysis of Agile and Lean Management Research in the Global Construction Industry

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Abstract: Despite the widespread integration of advanced technologies in construction projects, the construction sector's efficiency remains low, with persistent challenges related to waste, delays, resource use, and implementation. The objectives of the study are: (1) map research growth and productivity, (2) identify leading authors, Journals, and countries, and influential publications, and (3) reveal the conceptual structure and its evolution—particularly adoption-related constructs (factors, enablers, drivers, barriers, and critical success factors)—through integrated scientometric evidence. This research covers agile and lean construction research from 2005 to October 2025. The study adopted Bibliometrix in R and VOSviewer to analyze Scopus, WoS, and a merged de-duplicated dataset. Analysis revealed a clear dominance of lean construction research over agile project management, with the United States, the United Kingdom, and China emerging as the most significant contributors. Keyword co-occurrence indicates thematic linkages among project management, BIM, lean production, sustainability, and implementation-related issues, suggesting a shift toward a research agenda connecting process improvement, digitalization, sustainability, and adoption challenges. The merged database of 411 documents provided a broader view of lean and agile research. and reduced single-database bias. From a Sustainable Development Goals (SDGs) perspective, the findings are mainly associated with SDG 9 through innovation, infrastructure, and BIM-enabled digitalization, and with SDG 12 through resource efficiency, waste reduction, and responsible production. These SDG links are interpreted as literature-based thematic associations rather than direct empirical evidence of SDG achievement. The study provides a unified reference and highlights underexplored areas, particularly Lean–Agile integration, agile adoption in construction, and sustainability-oriented implementation pathways.

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1. Introduction

Despite its significant economic importance, the construction industry keeps suffering project performance issues, including delays, cost overruns, and process waste, underlining the critical need for evidence-based management changes. [1], [2], [3]

In the global economy, the construction industry is a major contributor and significantly affects gross domestic product (GDP) [4]. It also accounts for substantial annual expenditures associated with construction and ongoing maintenance activities [4]. In many countries, the construction industry is recognized as a vital economic sector that supports national income. [5], [6]. Against a backdrop of rapid global change, the construction industry has evolved into one of the fastest-growing sectors, driven by substantial infrastructure investment and expansion [7], [8] , [9]

While agile approaches enhance flexibility and collaboration under uncertainty, Lean construction reduces waste and improves flow efficiency. Considered together, they provide complementary responses to persistent construction delivery challenges, motivating their joint examination [4]. In general, a project is deemed satisfactory if it is completed on schedule, within budget, and with significant participant engagement in the project's outcomes [10]. Recurring waste arises during planning and design, materials management, and on-site construction activities [2]. The industry's efficiency remains below expectations despite the implementation of innovative technologies across construction projects [11].

Lean construction has been adopted to reduce wasteful practices in response to such waste-related inefficiencies that contribute to cost overruns and project delays [2], while agile methodologies are designed to welcome change, enabling teams to adjust their priorities and plans quickly [12]. The necessity for a field-level mapping that unifies and organizes the discourse is highlighted by the fact that evidence about the framing of adoption issues in the literature (such as barriers, enablers, and crucial success factors) is still dispersed across outlets and subtopics. [13], [14], [15] , [16]

Construction projects are more costly, intricate, and extensive, rendering them inherently risky; this complexity is further driven by larger project sizes, stricter standards, and sustainability requirements [17], [18]. Prior research identifies lean construction management and agile project management as crucial models for tackling cost control, project schedules, and sustainability issues, since the growing complexity of building projects demands the adoption of innovative approaches [17]. Managing these projects involves balancing cost management, effective time management, and sustainable practices, which has created significant challenges for the sector [17]. As projects have grown in complexity and scale, the need for innovative approaches to enhance productivity and deliver value has become increasingly apparent [19] , [20]

Lean is a production management method that has been successful in several industries, most notably the automotive industry [11]. Lean construction management is an approach based on lean manufacturing principles [17]. Lean construction, which is well-known for reducing waste and optimizing value in production systems, has been discussed in the literature as a potential approach for addressing efficiency and environmental concerns, in addition to productivity and competitiveness [4]. Agile approaches first appeared in the early 2000s in response to the shortcomings of traditional project management techniques and software development [21]. Agile project management is a contemporary approach that prioritizes adaptation, flexibility, and teamwork [4]. Applying agile technique may improve flexibility and collaboration, allowing teams to quickly adjust to changing project requirements and unforeseen obstacles, as evidenced by construction research [12]. The original purpose of this approach was for software development projects. However, as projects have become more complicated in recent years, its application has expanded into the construction sector. Agile project management has attracted considerable attention lately [17]. The importance of teamwork and communication in agile-oriented applications is further highlighted by recent studies

with a construction focus, which show that agile concepts are spreading—albeit unevenly—in construction project environments. [12], [15], [22], [23]

A search of Scopus and Web of Science using keywords related to agile project management, lean construction, and the construction industry, including terms such as bibliometric, systematic review, and literature review, revealed several studies addressing lean or agile in construction through literature reviews, systematic reviews, or bibliometric analyses. However, most of these studies focus on specific topics such as sustainability, the circular economy, building information modelling (BIM), labor productivity, or large-scale projects, and often address only lean construction or rely on a single database. As far as the authors are aware, there is no comprehensive bibliometric study that integrates Scopus and WoS data and examines the application of agile and lean management in the construction industry, focusing on the factors, enablers, drivers, barriers, critical success factors, and variables associated with their adoption.

Lean–BIM drivers [7], lean–sustainability integration [24], agile critical success factors for sustainable residential construction [15], the evolution of the circular economy in the construction industry ,and scientometric/bibliometric mappings centered on BIM integration themes [25] are examples of closely related topic-focused syntheses and mappings. Nevertheless, these efforts do not offer an integrated, de-duplicated Scopus–WoS map that jointly captures lean-and-agile construction management research at the field level.

The usefulness of a merged dataset is supported by methodological evidence that suggests analyzing Scopus and WoS independently may not offer a more comprehensive view of knowledge tendencies and may result in differences in productive authors, prominent articles, and keyword occurrences [26]. Because Scopus and WoS have different indexed-journal coverage and citation-source characteristics, depending solely on one database may distort the observed landscape of influential sources, collaboration patterns, and thematic signals. This is why this integration is important. [26], [27], [28]

Large-scale performance analysis and science mapping (e.g., co-authorship, co-citation, and co-word structures) that uncover the field's intellectual and conceptual structure and its evolution make bibliometric/scientometric approaches ideal for filling this gap. This allows them to supplement, not replace, the thoroughness of systematic literature reviews. [29], [30]

The most problematized adoption concerns in the literature can also be surfaced and organized by using keyword strategies and co-word/thematic mapping to investigate adoption-related constructs (such as "barriers," "enablers," and "critical success factors") in methodical manner. [26], [29], [30]. Conceptually, the present study organizes adoption-related constructs into driving/enabling conditions, constraining conditions and implementation-related success conditions. Within this scientometric design, these categories function as an organizing lens for corpus retrieval and interpretation, rather than as project-level causal variables. [7], [26], [29], [30].

1.1. Conceptual Framework and Analytical Lens

This study adopts a conceptual framework to guide the interpretation of lean and agile management research in the construction industry through scientometric evidence. The framework organizes the analysis around four connected elements: the construction research context, lean- and agile-related research streams, scientometric evidence, and analytical interpretation dimensions. The construction research context is characterized by persistent delivery challenges, including delays, cost overruns, process inefficiencies, project complexity, and increasing sustainability requirements. Within this context, lean-related research is interpreted as an efficiency-oriented stream associated with flow efficiency, value creation, process improvement, waste reduction, and the reduction of non-value-adding activities. Agile-related research is interpreted as an adaptability-oriented stream associated

with flexibility, responsiveness, collaboration, iterative adaptation, and adaptive management under uncertainty. As shown in Figure 1, the framework links these research streams to the study's scientometric analyses, including publication growth, productive authors, journals, countries, influential publications, citation patterns, keyword co-occurrence, clusters, and thematic evolution across Scopus, Web of Science, and the merged de-duplicated dataset. Adoption-related terms such as "drivers," "enablers," "barriers," "challenges," and "critical success factors" are treated as literature-framing constructs that show how implementation conditions are discussed in the literature, rather than as validated causal variables. Sustainability and SDG-related themes are also interpreted cautiously within this framework. Sustainability is treated as an emerging thematic direction connecting lean/agile construction research with BIM, digitalization, resource efficiency, green construction, circular economy thinking, and sustainable construction practices. SDGs are used only as a contextual lens were supported by the mapped themes, mainly SDG 9 and SDG 12.

Figure 1. Conceptual framework and analytical lens for interpreting Lean–Agile management research in the construction industry through scientometric evidence.

This study, therefore, aims to bridge this gap by conducting an integrated bibliometric analysis of agile and lean research in the construction industry, analyzing citation patterns, authors, countries, journals, and relevant major and emerging research topics.

To make the study objectives explicit and directly aligned with established science-mapping procedures and the rationale for a merged Scopus–WoS dataset, this study addresses the following research questions.

RQ1. What is the annual growth trajectory of lean and agile management research in the construction industry (2005–October 2025), and which journals, authors, documents, and countries are the most productive and influential?

RQ2. How do the science-mapping outputs differ when using Scopus-only, WoS-only, versus a merged and de-duplicated dataset, and what does this imply about potential database-driven bias in portraying the field?

RQ3. What are the dominant and emerging conceptual themes in lean/agile construction research, and how has the field's thematic focus evolved over time based on keyword co-occurrence networks and thematic mapping?

Within this thematic interpretation, sustainability-related findings are discussed in relation to construction-relevant priorities already emphasized in the cited literature, especially environmentally oriented lean implementation, lean–BIM-enabled delivery, circular-economy-oriented construction thinking, and sustainable residential/building applications. [7], [7], [15], [31]

By using a merged and de-duplicated dataset to provide a consolidated scientometric mapping of lean and agile management research in the worldwide construction sector, this work advances theory by clarifying the intellectual structure, collaboration patterns, and thematic evolution of the discipline. By exposing commonly studied adoption concerns (such as facilitators and obstacles) and emphasizing prevalent and developing themes, it advances practice by providing an evidence map that can aid in the decision-making process for improvement projects in the construction industry. Furthermore, it offers an open process that can be repeated in upcoming scientometric research on construction management. Methodological contribution: a transparent and replicable workflow for integrating Scopus and WoS and producing more stable mapping outputs than single-database approaches, supporting future construction-management scientometric studies.

1. Literature Review

1.1. Lean Project Management

The intellectual roots of lean methodology originate in the 1950s, with the development of the Toyota Production System (TPS), which focused on minimizing waste and streamlining workflow in the manufacturing environment [32]. Several decades later, in the early 1990s, lean thinking spread throughout industry and became a means to improve efficiency and enhance operational performance. Its success in manufacturing encouraged the transfer of the lean philosophy to the construction sector under the name "Lean Construction (LC)," where the literature indicates a link to improved business performance and enhanced competitiveness for organizations operating in this sector [33]. Other studies have also reported a growing interest in this philosophy within the construction industry and an increasing trend toward its adoption and implementation in projects globally [34]. Nonetheless, research focusing on the construction industry demonstrates that LC implementation is influenced by several critical success factors, such as managerial, cultural/human, and knowledge-related circumstances. Additionally, practitioners may use lean tools even if their conceptual understanding is less advanced than the level of application [32], [34].

In the ongoing industrial transformation, adequate time and resource management has emerged as a pivotal element in project success, facilitating the adoption of the lean construction methodology as a framework that seeks to enable project delivery within budget and on schedule by optimizing

available resources [35]. Several studies indicate that lean construction is currently being implemented by a growing number of construction companies worldwide to increase productivity, improve time, cost, and safety performance, and maximize customer value [36]. Empirical studies also link lean construction adoption to improved project outcomes and higher overall sector performance [37]. The necessity to integrate digitization initiatives with lean principles is highlighted by research from public-sector project delivery, which indicates that BIM mandates without a lean construction viewpoint may impede the desired outcomes [37].

Lean construction is the application of lean manufacturing principles to the construction project environment. The primary goal is to reduce or eliminate activities that do not add real value to the project while improving activities that directly contribute to value creation [38]. However, implementing these practices in construction projects remains a significant challenge for many teams, and maintaining their sustainability over time is increasingly complex due to the complexity of human factors and the multitude of stakeholders involved in projects [39]. According to data from the Indian construction sector, for instance, "managerial" and "inadequate resources" barriers rank among the main barriers to the implementation of lean construction, whereas "inadequate knowledge" and "just in time (JIT)" problems can be ranked as less influential [14]. Implementing lean construction focuses on three main pillars: maximizing customer value, establishing a principle of continuous improvement, and enhancing collaboration among the various parties involved in the project, resulting in efficient execution and high-quality coordination of activities [40]. The lean philosophy has also contributed to reshaping management and project management practices in the construction sector by focusing on process improvement, identifying and eliminating waste, and maximizing value for internal and external clients [13]. Given the shortcomings of traditional methods in addressing many recurring problems in construction projects, lean is now presented as a methodological option that offers advantages, including efficient resource utilization, controlled execution timelines, and support for environmental sustainability. It is also viewed as a strategic investment that distinguishes serious organizations in a sector that deals with long-life assets, rather than fast-moving consumer goods [14].

1.2. Agile Project Management

The Agile Manifesto, published in 2001, is considered the starting point for the emergence of the agile project management methodology [41]. It is a symbolic document signed by a coalition of 17 participants who called themselves " Agile Alliance." This manifesto includes four core values and 12 principles to promote flexibility, teamwork, and customer-centricity within the project workflow [21]. Agility refers to the ability to innovate and adapt quickly to change. This capacity adds value in a volatile business environment by fostering a culture of continuous learning, experimentation, and improvement [41]. Agile project management originated in the software industry, where it relied on small, self-organizing, multidisciplinary teams working within a framework of trust, open communication, and transparent processes [10], [42]. However, to foster multi-skilled and self-managing teams, implementing new management approaches like Agile requires a substantial cultural shift [12].

These teams deliver project requirements incrementally through a limited number of iterations, relying on iterative development and frequent feedback [15], [27]. Agile principles offer a path toward greater responsiveness in tasks and processes, which aligns with the accelerating pace of work in the construction industry and the increasing demands of clients for project completion within tight deadlines [12]. According to survey-based data from the construction industry in developing countries, Agile Project Management is becoming increasingly popular as a solution to persistent problems with project performance, such as schedule delays, cost overruns, and quality failures [43].

Implementing an agile strategy aims to increase team productivity through knowledge-based decision-making, reduced hierarchical levels, and enhanced collaborative governance and effective teamwork [43]. Agile methodologies stem from the recognition of the difficulty in predicting the future and incorporate explicit approaches to dealing with changes as they arise, unlike traditional project management approaches that assume stable conditions and clearly defined requirements from the outset [26], [30]. Projects are typically managed under varying degrees of uncertainty and disruption, while rigid, sequential approaches only cover a limited portion of the risks associated with uncertainty [44]. In contrast, the contemporary trend toward more agile project management reflects the adoption of the agile approach, which provides a flexible management system that enables real-time adaptation to changing conditions [44] . The primary benefit of agility as a general project management approach is its ability to enhance a team's capacity to respond to problems as they arise, thereby increasing the likelihood of project success [45].

This has led to a gradual shift from traditional project management to agile project management, with growing interest in its application to construction projects and an increasing volume of research on the subject [12], [46] Furthermore, to enable project managers adopt a more flexible approach, an Agile Quality Management Framework has been proposed for the construction industry to track alignment and points of contact between Scrum practices and PMBOK® processes throughout the project lifecycle [35]. Research on the applicability of agile management in construction projects remains relatively limited but is expanding, as construction companies explore how agile components can support their transformation into more innovative organizations [28], [35]. In this context, agility emerges as a concept that offers new opportunities to improve construction project management, where communication plays a pivotal role in developing project teams and strengthening stakeholder relationships [22]. Agile project management is a transformative methodology for managing complex projects, particularly when requirements are fluid or complicated to define precisely early on. It can support more sustainable practices in the construction sector by enhancing adaptability, encouraging collaboration, and improving resource management [15]. Although some researchers differentiate between agile and lean, both agile techniques and lean construction place strong emphasis on teamwork, collaboration, and delivering added value to the client. Both agile and lean construction place great importance on flexibility and adaptability to changing project needs or client demands [42]. Hybridization and Lean–Agile synergies (including the combination of "traditional," "agile," and "lean" approaches) are also specifically examined in recent construction-oriented scholarship, suggesting an emerging direction for striking a balance between flow efficiency and responsiveness in the face of uncertainty. [35]

To strengthen the analytical synthesis of the literature, Table 1 compares lean and agile perspectives using the studies reviewed in this manuscript. The purpose of this comparison is not to claim that lean and agile are identical approaches, but to clarify their distinct managerial logic, areas of overlap, and relevance to construction project challenges.

Table 1. Comparative synthesis of lean and agile perspectives in construction research

Analytical dimension	Lean construction perspective	Agile project management perspective	Synthesis for the present study
Primary managerial logic	Lean construction is mainly associated with improving project delivery, enhancing flow efficiency, supporting value generation, and reducing non-value-adding activities. This is supported by studies examining lean construction effectiveness, lean implementation drivers, and successful lean implementation models [2], [11]	Agile project management is mainly associated with responsiveness, adaptability, flexible management, iterative coordination, and adaptive decision-making in uncertain construction project environments. This is supported by studies on agile management principles, agile practices in construction, and agile project management in the pre-construction stage [4], [12]	Lean and agile address different but related construction management needs. Lean emphasizes discipline and efficiency, while agile emphasizes adaptability and responsiveness. This justifies examining both streams together without treating them as interchangeable.
Construction problems addressed	Lean construction studies are commonly connected with improving project delivery, reducing waste, enhancing productivity, and addressing implementation barriers that affect construction performance [2], [13], [14]	Agile construction studies are commonly connected with managing changing project conditions, pre-construction challenges, communication, stakeholder interaction, and project performance improvement under uncertainty [12], [22]	Construction projects face both efficiency-related problems and uncertainty-related problems. Therefore, a field-level mapping of both lean-oriented and agile-oriented research themes is justified.
Adoption and implementation focus	Lean research gives strong attention to implementation drivers, barriers, critical success factors, and sustaining lean implementation in construction projects [33], [34]	Agile research gives attention to critical influential factors, communication, quality management frameworks, cultural change, and critical success factors for agile adoption in construction contexts [4], [15]	Adoption-related constructions such as drivers, enablers, barriers, challenges, and critical success factors are relevant to both streams. In this study, these constructs are treated as literature-framing themes that can be mapped through keyword co-occurrence and thematic clustering.
BIM and digitalization connection	Lean research is directly connected with BIM through studies on lean–BIM implementation drivers and BIM as an enabler of lean construction in project delivery [7], [37]	Agile-related research is more indirectly connected with digitalization through adaptive coordination, collaboration, and flexible project delivery; however, its connection with BIM appears less consolidated than the lean–BIM stream [12], [22]	BIM provides a relevant thematic bridge where process improvement, information flow, collaboration, and adaptive delivery are discussed in the construction literature. However, the expected scientometric visibility of BIM is likely to be stronger in lean-related research than in agile-related research.
Sustainability orientation	Lean construction has been directly examined in relation to environmental sustainability,	Agile project management has been directly examined in relation to sustainable residential construction	Sustainability is relevant to both streams, but in this study, it should be interpreted cautiously

Analytical dimension	Lean construction perspective	Agile project management perspective	Synthesis for the present study
	sustainable construction practices, waste reduction, and resource efficiency [24]	through critical success factors and adaptive project delivery considerations [15]	as a literature-based thematic direction, not as a directly measured project outcome.
Implication for scientometric analysis	Lean appears as a relatively mature construction management stream because the reviewed literature includes several studies on lean effectiveness, implementation drivers, barriers, critical success factors, and sustainability-related applications [33], [34]	Agile appears as a growing but comparatively less established stream in construction management, with studies focusing on agile principles, pre-construction challenges, communication, quality management, and critical success factors [4], [12], [41]	The present scientometric analysis is therefore positioned to examine the relative visibility, overlap, and thematic evolution of lean and agile research streams in construction, rather than assuming that both streams are equally developed.

The comparison shows that lean and agile approaches share an interest in improving construction project delivery, collaboration, and value creation, but they differ in their dominant managerial logic. Lean construction is more strongly associated with flow efficiency, process improvement, and reduction of non-value-adding activities, while agile project management is more strongly associated with responsiveness, adaptability, team communication, and iterative management under uncertainty. This synthesis supports the rationale of the present study by showing that construction research requires a field-level scientometric map capable of capturing both mature lean-oriented themes and emerging agile-oriented themes, as well as their links with BIM, sustainability, and adoption-related issues.

2. Methodology

This section details the methodological workflow adopted in the present study to map and analyze agile and lean management research in the construction industry using bibliometric and scientometric techniques. To address transparency, logical flow, and reproducibility, the workflow is presented in a study-specific, stepwise manner: (1) database selection; (2) query design and eligibility criteria (keywords, timeframe, document types, language); (3) record export and conversion; (4) merging and de-duplication; (5) performance analysis; and (6) science mapping (co-authorship, co-citation, and keyword co-occurrence) and thematic interpretation. [26], [28], [29]

Accordingly, the following sub-sections prioritize the operational steps and parameter choices used in this study, while the brief bibliometric/scientometric background is provided only to justify the selected techniques and indicators.

It has been observed that the development of scientific databases such as Scopus and WoS has made it easier to obtain extensive bibliometric information [29]. Because of their accessibility and sophisticated search features, which allow researchers to find relevant studies across a variety of subject areas [47], these two databases are primarily used as sources of scientific publications in bibliometric studies [28]. Web of Science (WoS) is one of the oldest scientific databases [28]. WoS was the leading source of bibliometric data until Elsevier launched Scopus in 2004, which quickly became its main competitor [28]. Compared to the Web of Science index, Scopus is notable for including more recent scientific publications [27]. Scopus outperforms Web of Science in terms of the quantity of indexed journals and records, as well as the diversity of its citation data sources, despite Web of Science's superiority in the depth of its scientific citation data [27]. According to recent bibliometric studies, the majority of research uses either Scopus or Web of Science [30]; therefore, choosing the correct database is essential to guarantee a thorough and reliable bibliometric study [28]. While some researchers prefer a combined dataset to obtain more comprehensive and reliable findings, the majority of bibliometric studies do not merge data from both databases into a single, integrated analysis [26]. Accordingly, to leverage the complementary coverage of the two databases and reduce the risk of single-database bias, this study retrieved records from both Scopus and WoS and then merged them into a single de-duplicated dataset for the subsequent analyses (Section 3.2). Thus, database choice, query construction, eligibility filters, and merging/de-duplication are treated here as core design decisions (not incidental technical steps), because they directly influence coverage, comparability, and the stability of the resulting science maps and indicators. [26], [28], [29].

2.1. Information Gathering

The search strategy in this study involved the systematic use of logical operators ("AND" and "OR") together with a carefully selected set of keywords. Major keywords related to agile and lean, including "agile project management", "lean construction", and "lean project management", were used as search terms in both Web of Science and Scopus. The search was then narrowed further to the construction industry using the terms "construction industry" and "construction projects". The results were additionally filtered to focus on factors influencing the implementation of lean construction in projects, such as "barriers", "enablers", and "critical success factors". To maintain analytical consistency, the search was limited to English-language journal articles and reviews published between 2005 up to October 2025. This search yielded 323 documents in Scopus and ٢٨٣ documents in Web of Science.

(A) Keyword selection.

The keyword set was selected to balance breadth and precision: (i) "Agile/Agile Project Management /APM" and "Lean Construction/Lean Project Management" capture the two focal management paradigms; (ii) "Construction Industry/Construction Projects" restricts retrieval to the construction domain; and (iii) the adoption-related terms (factors/enablers/drivers/barriers/challenges/success factors/variables) align the corpus with the study objective of mapping implementation conditions and constraints. [29]

(B) Timeframe.
The timeframe (2005–2025) was used to capture the modern development of lean and agile research in construction while ensuring a sufficiently large and comparable publication window across the two databases for trend and network analyses. [29], [48]
(C) Document types and language.
Only peer-reviewed journal ARTICLES and REVIEWS in English were retained to enhance comparability and quality consistency of the scientometric indicators, while excluding document types with heterogeneous review processes (e.g., editorials, notes, and conference items). [29]
For reproducibility, the exact advanced-search syntax used in Scopus and Web of Science is reported below. Scopus (Advanced query): (TITLE-ABS-KEY ("Agile " OR "Agile Project Management" OR "APM" OR "Lean Construction" OR "Lean Project Management") AND TITLE-ABS-KEY ("Construction Industry" OR "Construction Projects") AND TITLE-ABS-KEY ("Factors" OR "Enablers" OR "Drivers" OR "Barriers" OR "Challenges" OR "Success Factors" OR "Variables")) AND PUBYEAR > 2004 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English"))
WoS (Advanced query): TS= (("Agile" OR "Agile Project Management" OR "APM" OR "Lean Construction" OR "Lean Project Management") AND ("Construction Industry" OR "Construction Projects") AND ("Factors" OR "Enablers" OR "Drivers" OR "Barriers" OR "Challenges" OR "Success Factor*" OR "Variables")) AND PY=(2005-2025) AND DT=(Article OR Review) AND LA= (English)
The searches were executed on 17 October 2025.
Reporting the full query strings, eligibility criteria, and execution date supports reproducibility because database contents and indexing coverage can change over time. [28], [29]

2.2. Merging Data

In this study, adoption-related constructs (e.g., factors, enablers, drivers, barriers, and critical success factors) were operationalized through the search query terms (Section 3.1) and then identified and interpreted using keyword co-occurrence networks and thematic clustering outputs (Section 4.6). No additional manual content analysis or thematic coding of titles/abstracts/full texts was performed; therefore, the reported “factors/enablers/barriers” insights reflect the corpus-level keyword evidence and its network structure. Accordingly, these constructs function as a screening and structuring lens to map where and how adoption issues are discussed in the literature and to identify candidate issues for subsequent empirical survey development, rather than to finalize a validated factor inventory within this bibliometric study.
In according to Echchakoui [26], records from Scopus and WoS were merged to overcome the limitations of single-database analysis and create a more comprehensive, de-duplicated dataset. To obtain a dataset with 411 papers included for our bibliometric analysis, we first exported files from Scopus and WoS as “bib files". Next, we used Biblioshiny in RStudio to convert the two files into Bibliometrix files. Finally, we merged the files into a single file in RStudio and eliminated duplicates [47]. Duplicate records were identified primarily using DOI; when DOI was unavailable, matching was performed using the title, first author, and publication year, followed by a manual check. This explicit DOI-first matching strategy (with title/author/year fallback) is reported to ensure that the de-duplication protocol can be replicated and audited by other researchers. [47]
In this study, VOSviewer (Visualization of Similarities), a widely used free bibliometric analysis program, was used to analyze and visualize relationships between authors, countries, keywords, co-citations, and terms [25]. VOSviewer employed full counting, which assumes that each association has equal weight, [38], [47]. Minimum-threshold settings were used as a regular filtering step prior to map construction to improve interpretability and decrease visual noise in dense bibliometric networks. To preserve recurrent and analytically significant nodes while eliminating infrequently occurring elements that may split clusters and make maps less readable, the thresholds were chosen as conservative cut-

offs. While Bibliometrix/Biblioshiny was chosen for its transparent conversion, cleaning, and merging within an R-based workflow, VOSviewer was chosen for its robust construction and visualization of large co-authorship/co-citation/co-word networks and for its ability to produce consistent, comparable maps across analyses. Together, their complementary capabilities support a logical and repeatable end-to-end scientometric pipeline. [25], [47], [48]

To directly address parameter transparency, the main analyses applied baseline minimum thresholds of ≥5 because these conservative cut-offs retain recurrent signals while limiting long-tail noise that can fragment clusters and reduce readability; the exact thresholds used are reported alongside each corresponding map and table in Section 4.
Different thresholds were used because the analyses capture different types of scientometric evidence. A minimum occurrence threshold of 5 was applied to keyword and co-word analyses to retain recurring thematic signals while preserving emerging but conceptually relevant topics, including agile- and sustainability-related terms where they appear sufficiently in the corpus. A substantially higher keyword threshold could have excluded less frequent but important themes and reduced the ability of the study to interpret thematic evolution. Therefore, the threshold of 5 was considered appropriate for balancing thematic breadth, interpretability, and cross-dataset comparability in the keyword and co-word networks.
By contrast, the citation analysis used a higher threshold of 20 citations because its objective was to identify documents with measurable intellectual influence within the corpus, rather than to maximize thematic breadth. Citation analysis is concerned with intellectual impact, whereas keyword co-occurrence analysis is concerned with thematic structure; therefore, the two analyses require different inclusion thresholds. In this study, the citation threshold retained 129 of 283 WoS documents, 129 of 323 Scopus documents, and 186 of 411 merged-dataset documents, indicating that the threshold was selective enough to focus on influential publications but not excessively restrictive.

Applying a common baseline threshold of ≥5 across the main co-country and co-word analyses also supported comparability across WoS, Scopus, and the merged dataset. [25], [47]
In contrast to fractional counting, which allocates weights among co-authors or co-occurrences and may produce varying link intensities and ranks, full counting was used to highlight the overall observed link strength in the networks.
Full counting was retained because the study aims to map the overall visibility and observed link strength of authors, countries, keywords, and documents across the three datasets. This approach is consistent with the study's field-level objective, which focuses on occurrence counts, total link strength, and database-level comparison rather than proportional contribution attribution. Fractional counting would be more suitable for studies aiming to distribute credit among co-authors, countries, or shared keyword links; however, this is not the primary aim of the present study.

This choice is consistent with the aims of the present study, which interpret network prominence mainly through occurrence counts and total link strength across WoS, Scopus, and the merged dataset. Under fractional counting, records involving many co-authors, countries, or co-occurring keywords would receive divided weights, which could reduce absolute link-strength values and slightly shift the relative prominence of some nodes and links in the visual maps. [47], [48]
Another free software package, Bibliometrix, was also employed in this study [48]. Bibliometrix for RStudio includes an inbuilt utility, Biblioshiny, with a graphical interface for non-coders, resulting in comprehensive analysis with improved plot representation [48]. VOSviewer was used primarily for network construction and visualization, whereas Bibliometrix/Biblioshiny was used for data conversion, cleaning, and performance indicators within the R environment. Fig. 2 illustrates the research design, starting from database selection and proceeding to analysis in VOSviewer and Bibliometrix-R.

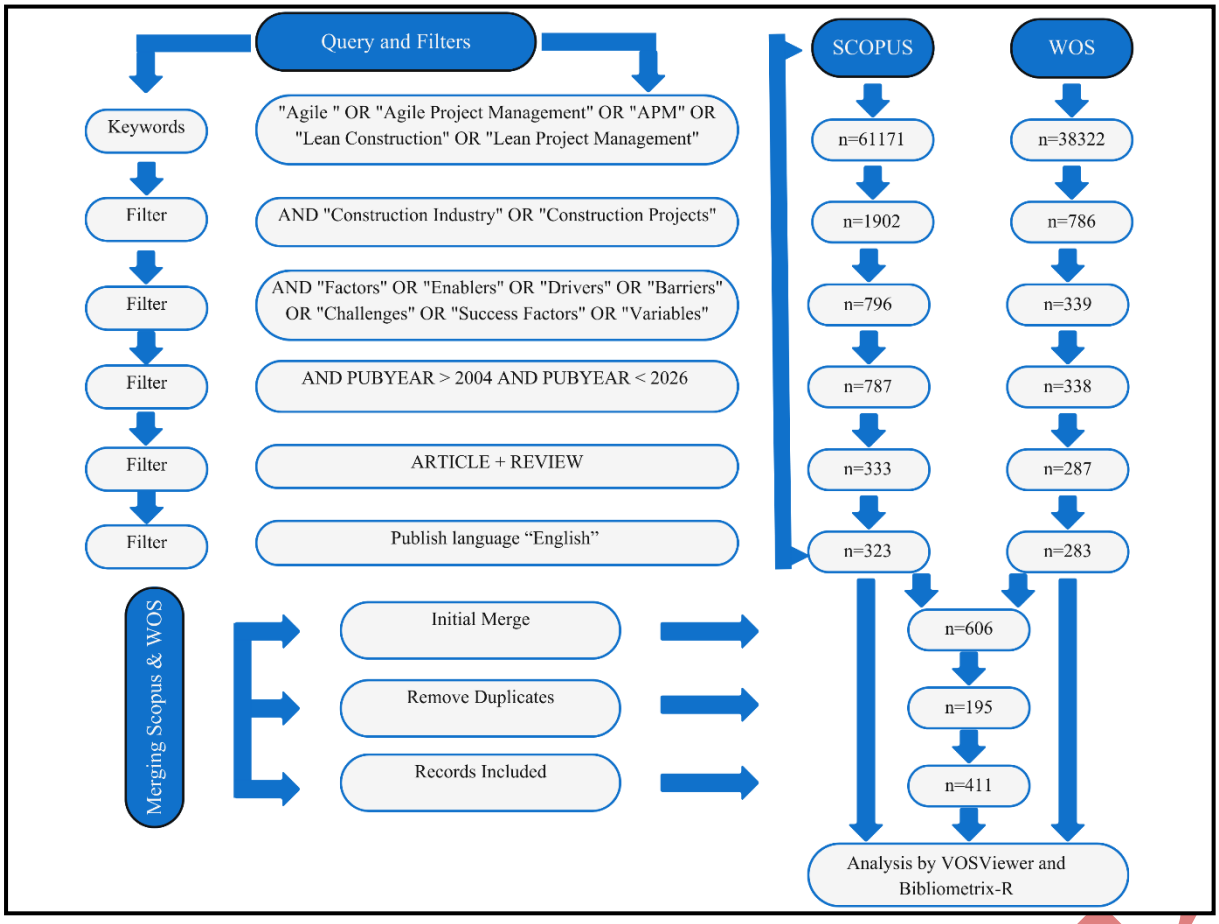


Figure 2. Research methodology.

3. Results And Analysis

3.1. Information about the Data

The top bibliometric metrics from WoS, Scopus, and the merged database for the period 2005 to 2025 are compiled in Table 2. Search results have been filtered to include only articles and reviews. Consistent with the study's integrated mapping objective, the merged and de-duplicated dataset is used as the primary basis for substantive interpretation throughout the Results and Discussion, whereas the WoS-only and Scopus-only outputs are retained mainly to illustrate database-specific variation and support RQ2 on potential database-driven bias.[26], [27], [28]

After removing duplicates, the merged database contained 411 entries, whereas Scopus had 323 publications, approximately 14% more than WoS (283). While the merged database had 143 sources, Scopus indexed more (126) than WoS (89). Although the average document age in Scopus was somewhat less (5.17 years vs. 5.24 years), the annual growth rate of publications in WoS was greater (18.94%) than in Scopus (12.56%). Citations per WoS document were higher (38.7) than the corresponding value for Scopus (32.85). Notably, the merged dataset yields 411 unique records compared to the combined total of 606 records from the two databases (323 + 283), indicating that 195 records would have been double counted without the de-duplication step.

In terms of author keywords, Scopus provided about 6% more than WoS (910 vs. 856). Nonetheless, the number of authors was 10% higher in Scopus than WoS (860 in Scopus vs. 777 in WoS). WoS had a higher rate of international co-authorships (36.04%) compared to Scopus (28.79%). Finally, journal

articles dominated both databases, with Scopus reporting slightly more (297 vs. 255). In contrast, WoS had 28 review articles rather than 26 in Scopus.

Table 2. Main information of agile and lean publications in Scopus, WoS, and merged databases.

Description	WoS	Scopus	Merged
Timespan	2005:2025	2005:2025	2005:2025
Sources (Journals, Books, etc.)	89	126	143
Documents	283	323	411
Annual Growth Rate %	18.94	12.56	13.23
Document Average Age	5.24	5.17	5.59
Average citations per doc	38.7	32.85	38.78
References	15021	2306	8724
Keywords Plus (ID)	453	1422	1638
Author's Keywords (DE)	856	910	1167
Authors	777	860	1106
Authors of single-authored docs	9	17	18
Single-authored docs	9	17	19
Co-Authors per Doc	3.21	3.25	3.23
International co-authorships %	36.04	28.79	21.17
article	255	297	379
review	28	26	32

3.2. Research Growth

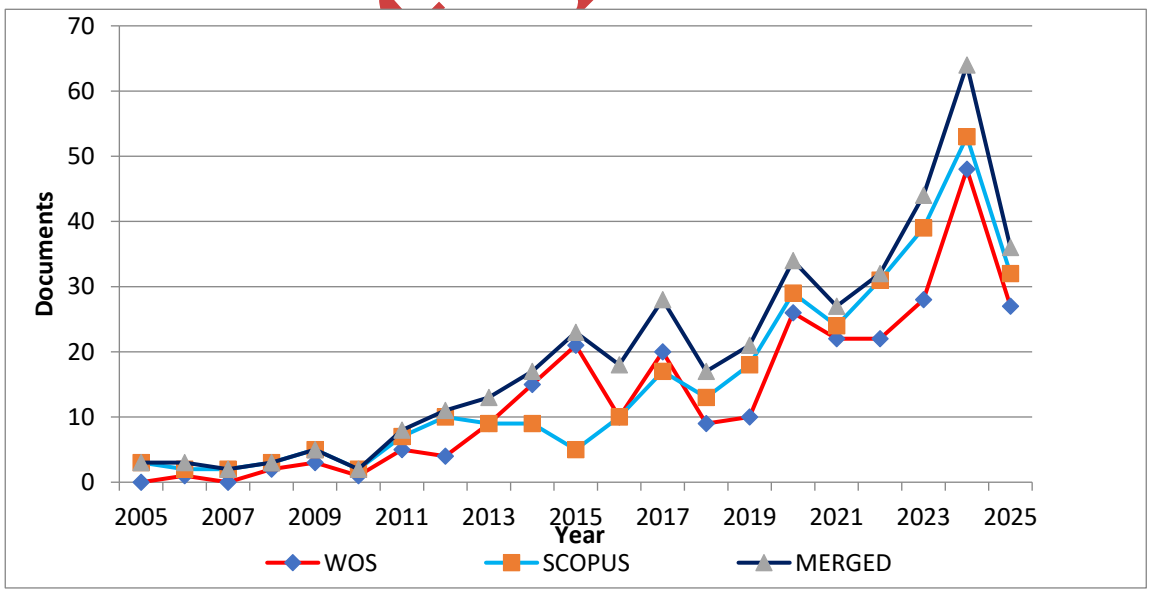


Figure 3. Annual publication in WoS, Scopus, and merged databases.

Figure 3 indicates that most of the publication acceleration occurred in the last decade, suggesting a recent intensification of research attention to agile and lean management in construction. Both WoS and Scopus show an increasing annual trend with fluctuations. However, the integrated dataset shows that there was a steady increase in the number of publications after 2015, with a strong rise in output in 2020, and a peak in 2024 with 70 publications. This suggests that interest in agile and lean construction

has grown significantly in recent years, reflecting the industry's increasing focus on efficiency, flexibility, and project performance.

3.3. Most Productive Authors

The top four authors in the merged database are Bajjou MS (8 publications, h-index = 7), Chafi A (8 publications, h-index = 7), Demirkesen S (7 publications, h-index = 6), and Aslam M (7 publications, h-index = 5). Although the leading authors are clearly identifiable, their publication counts remain small relative to the total corpus (e.g., 8 papers out of 411 in the merged dataset), indicating that the field is distributed across a broad set of contributors rather than dominated by a single research group.

Other names include Evans M, Farrell P, Gao ZL, and Smith G (each with 5-6 publications). After eliminating duplicates, the merged database offers more comprehensive view. It also highlights names like Oke AE and Hosseini MR, whose presence was less prominent in separate databases. These database-dependent differences indicate that author productivity rankings are sensitive to indexing coverage and duplicate records; therefore, the merged dataset provides a more reliable representation of the core contributor landscape. Moreover, the appearance of additional authors in the merged list suggests that combining databases helps capture contributors that may be underrepresented when using a single index.

Table 3. Most relevant journals in WoS, Scopus, and merged databases.

WoS				Scopus				Merged			
Sources	Articles	h-index	TC	Sources	Articles	h-index	TC	Sources	Articles	h-index	TC
International Journal of Project Management	63	45	6625	Buildings	26	13	495	International Journal of Project Management	66	46	7353
Buildings	23	11	294	Engineering, Construction and Architectural Management	22	13	626	Buildings	28	14	522
Engineering, Construction and Architectural Management	21	10	428	Journal of Construction Engineering and Management	15	11	655	Engineering, Construction and Architectural Management	24	13	629
Sustainability	11	5	94	Sustainability	14	6	155	Journal of Construction Engineering and Management	16	12	670
Construction Innovation	10	8	162	International Journal of Project Management	13	12	2516	Sustainability	14	6	156
International Journal of Construction Management	9	7	242	Construction Innovation	13	10	481	Construction Innovation	13	10	482
Journal of Engineering, Design and Technology	7	6	202	Lean Construction Journal	13	6	199	Lean Construction Journal	13	6	199
Smart and Sustainable Built Environment	7	5	79	International Journal of Construction Management	10	8	239	International Journal of Construction Management	11	9	309
Journal of Cleaner Production	6	6	432	Journal of Management in Engineering	8	8	594	Smart and Sustainable Built Environment	9	6	125
Journal of Construction Engineering and Management	5	4	131	Construction Management and Economics	7	6	196	Journal of Cleaner Production	8	8	637
EMJ - Engineering Management Journal	5	4	90	Smart and Sustainable Built Environment	7	6	114	Journal of Management in Engineering	8	8	594
Journal of Management in Engineering	4	4	174	Journal of Cleaner Production	6	6	547	Journal of Engineering, Design and Technology	7	6	250
International Journal of Productivity and Performance Management	4	3	84	Journal of Engineering, Design and Technology	6	5	237	Construction Management and Economics	7	6	196

WoS				Scopus				Merged			
Sources	Articles	h-index	TC	Sources	Articles	h-index	TC	Sources	Articles	h-index	TC
Ain Shams Engineering Journal	4	2	87	International Journal of Civil Engineering and Technology	5	4	41	Revista Ingeniería de Construcción	6	2	83
Revista Ingeniería de Construcción	4	2	45	EMJ - Engineering Management Journal	5	3	105	Ain Shams Engineering Journal	5	3	108
Automation in Construction	3	3	57	Revista Ingeniería de Construcción	5	2	83	International Journal of Civil Engineering and Technology	5	4	41
Construction Economics and Building	3	2	96	Ain Shams Engineering Journal	4	2	58	Automation in Construction	4	4	185
International Journal of Lean Six Sigma	3	2	53	Automation in Construction	3	3	174	EMJ - Engineering Management Journal	٥	٤	105
Built Environment Project and Asset Management	3	2	23	Journal of Financial Management of Property and Construction	3	3	48	International Journal of Productivity and Performance Management	4	3	101
Civil Engineering Journal-Tehran	3	2	23	Construction Economics and Building	3	2	122	International Journal of Lean Six Sigma	4	2	95

3.4. Most Relevant Journals

The results in Table 3 present the most relevant journals in Scopus, Web of Science, and the merged database. It is noted that the International Journal of Project Management appears as the most productive and influential journal in the merged database (66 articles, h-index=46, total citations=7353), with a difference in coverage between the two indexing databases, as it appears in the WoS database (63 articles, h-index=45, total citations=6625) and in the Scopus database with fewer entries (13 articles, h-index=12, total citations=2516), highlighting the impact of database merging and duplicate removal in providing a more comprehensive view of journal output.

Buildings rank second in the merged database (28 articles, h-index=14, total citations=522) and in the WoS database (23 articles, h-index=11, total citations=294). Based on the merged database, the most productive journals are the International Journal of Project Management, Buildings, and Engineering, Construction and Architectural Management.

Overall, the leading journals identified in the merged dataset suggest that lean–agile construction research is anchored in both project management outlets (e.g., International Journal of Project Management) and construction-focused innovation and sustainability venues (e.g., Construction Innovation, Buildings), reflecting a thematic convergence between delivery performance, digitalization, and sustainability concerns.

3.5. Most Productive Country

The results for scientific production (documents) in Table 4 show a high degree of convergence at the top, with slight differences in ranking across the three databases. In the merged database, the United States (51) dominates, followed by the United Kingdom (49), then China (46), with Egypt, Nigeria, and Malaysia also present in the top ten. Overall, the United States, the United Kingdom, and China are consistently among the top tier, though their positions vary across databases. The leading positions of these countries in the merged dataset suggest a concentration of lean–agile construction research output in major research economies, while the presence of countries such as Egypt, Nigeria, and Malaysia within the top ten indicates a widening geographical participation beyond the traditional core.

Table 5 shows the top twenty cited countries from 2005 to 2025. In the merged database, the United Kingdom is the most cited country, with 2,865 citations, followed by Australia (2,521) and China (2,404). Taken together, the results indicate that productivity (document counts) and impact (citations) do not necessarily coincide for example, the United States appears particularly influential in Scopus and merged database by document counts, whereas the United Kingdom leads the total citations in the three databases

Figure 4A and Figure 4B show established international collaboration structures in the WoS and Scopus databases, respectively, with seven clusters in WoS and six in Scopus.

The merged database comprises eight clusters, as shown in Figure 4C. Jordan, Brazil, and France belong to the first cluster (red); China, Turkey, Singapore, and India belong to the second (green); Malaysia, Palestine, and Qatar belong to the third (blue); Canada and New Zealand belong to the fourth (yellow); the United Kingdom and Australia belong to the fifth (purple); Egypt and Nigeria belong to the sixth (cyan); Spain and Germany belong to the seventh (orange); and the United States and Pakistan belong to the eighth (brown). Across the three maps, the consistent leadership of the United States, the United Kingdom, and China suggests that these countries function as central hubs in international collaboration within lean–agile construction research. The additional clusters visible in the merged map support the interpretation that database integration provides a clearer picture of global collaboration structure by capturing links that may be missed in single-database networks.

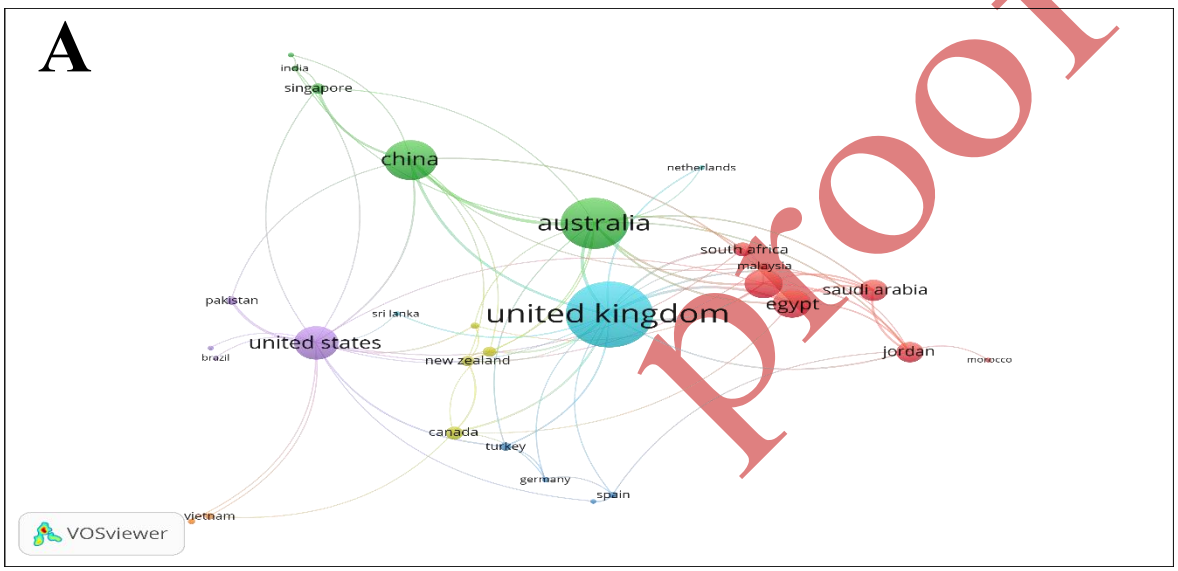
Table 4. Corresponding author's countries in WoS, Scopus, and merged databases.

WoS		Scopus		Merged	
Country	Documents	Country	Documents	Country	Documents
United Kingdom	38	United States	40	United States	51
China	38	United Kingdom	36	United Kingdom	49
Australia	34	India	32	China	46
United States	31	Australia	29	Australia	40
India	20	China	24	India	36
Malaysia	14	Malaysia	18	Malaysia	22
Turkey	13	Canada	15	Canada	16
Egypt	13	Egypt	14	Egypt	15
Iran	11	Nigeria	13	Nigeria	15
New Zealand	11	Turkey	13	New Zealand	15
Nigeria	11	New Zealand	12	Iran	14
Singapore	10	Spain	12	Turkey	14
South Africa	10	Brazil	12	Brazil	14
Morocco	10	South Africa	10	South Africa	12
Canada	10	Jordan	9	Spain	12

Spain	9	Saudi Arabia	9	Singapore	12
Brazil	9	Iran	9	Norway	10
Finland	8	Norway	9	Morocco	10
Chile	7	Finland	9	Finland	10

Table 5. Total Citations by country in WoS, Scopus, and merged databases.

WoS		Scopus		Merged	
Country	Citations	Country	Citations	Country	Citations
United Kingdom	2452	United Kingdom	2663	United Kingdom	2865
Australia	2133	Australia	1969	Australia	2521
China	1968	United States	1669	China	2404
United States	1138	Spain	1236	United States	2171
Spain	875	Germany	1042	Spain	946
Singapore	783	China	1039	India	907
India	777	India	1013	Singapore	783
Germany	767	Singapore	493	Germany	771
Iran	517	Egypt	356	Iran	540
Turkey	366	Morocco	332	Malaysia	428
South Africa	327	Canada	329	Turkey	396
Malaysia	323	United Arab Emirates	323	South Africa	340
Taiwan	320	Turkey	311	Taiwan	320
Morocco	317	Malaysia	302	Morocco	317
Chile	299	South Africa	284	New Zealand	313
Netherlands	272	New Zealand	247	Canada	307
South Korea	260	Chile	241	Chile	299
New Zealand	257	Iran	228	South Korea	292
Egypt	246	Nigeria	208	Netherlands	272
United Arab Emirates	229	Jordan	208	Egypt	264



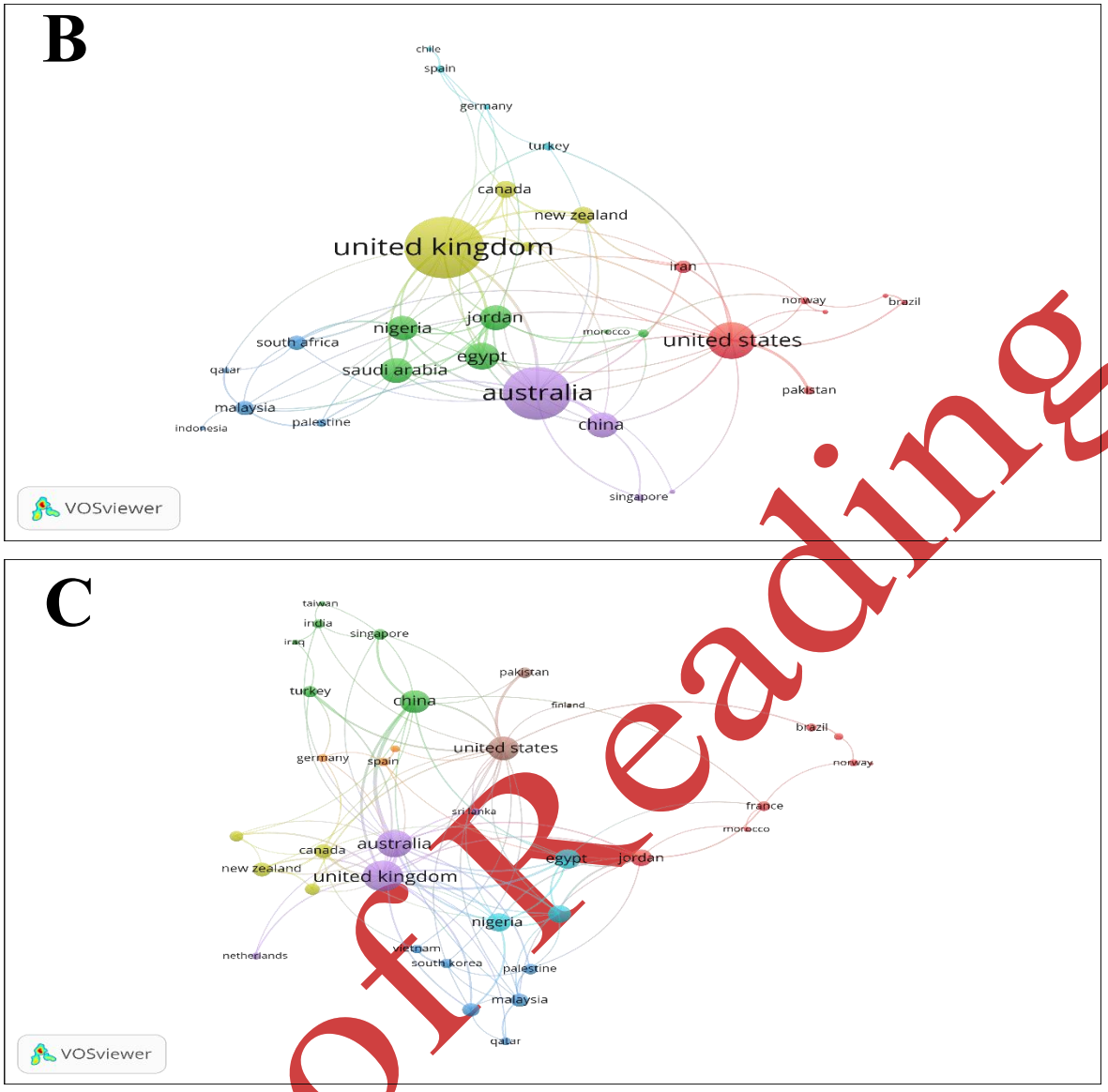


Figure 4. Co-countries collaboration in: (A) WoS database. (B) Scopus database. (C) Merged database.

3.6. Most Frequent Keywords

This study analyzes keyword frequencies and occurrences, as well as their total link strength. Table 7 presents the top twenty keywords associated with lean/agile literature across the three databases from 2005 to 2025. The results show that the most frequent keyword in the merged database is "lean construction" with 219 occurrences and a total link strength of 1183, followed by "construction industry" (182 occurrences and 1143 total link strength), and then "project management" (109 occurrences and 748 total link strength). The keyword "lean construction" is also the most frequent occurring in both Scopus and WoS, appearing 200 times in Scopus and 124 times in WoS, respectively. Overall, the dominance of “lean construction” and related terms across the frequency list indicates that the scientometric landscape in this domain is primarily shaped by lean-oriented studies. In addition, the presence of “BIM/building information modelling” and “sustainability” among the frequent keywords suggests that lean–construction research is increasingly intertwined with digitalization and sustainability-related themes. Moreover, the appearance of “implementation” and “barriers” among the most frequent terms indicates that adoption-related issues (barriers/enablers and implementation

concerns) represent a recurring stream in the literature, which directly aligns with the study's objective of mapping factors and adoption challenges.
However, the subsequent keywords show different patterns of relevance between the merged and WoS databases. "management" ranks second in WoS, with 71 occurrences, followed by "implementation" with 65. In Scopus, "construction industry" ranks second with 172 occurrences, consistent with its ranking in the merged database. In comparison, "lean production" ranks third with 102 occurrences, whereas in the merged database, "project management" ranks third. Notably, explicit agile-related terms do not appear among the top twenty keywords in the merged list (Table 7), which suggests that agile management remains a smaller and less integrated research stream compared with lean-oriented studies in the construction domain. These differences also indicate that keyword prominence can vary by database coverage; therefore, the merged dataset is used as the primary basis for thematic interpretation in the subsequent network maps.

The analysis was designed to identify and map emerging topics related to the lean/agile literature. It encompassed all keywords found in the retrieved studies, with a minimum threshold of five occurrences per keyword required for inclusion in the analysis network. A minimum keyword-occurrence threshold of 5 was used to focus the co-occurrence analysis on recurring themes and to reduce the influence of sporadic or idiosyncratic terms that are less reliable for cluster interpretation.
In the WoS database, 1,201 keywords were extracted, of which 97 met the inclusion criteria. In the Scopus database, 1,942 keywords were extracted, of which 119 met the threshold. The merged database included 2,373 keywords, of which 157 met the analysis requirements. Figure 5 illustrates the network of the most frequently occurring keywords and their chronological evolution. The colored nodes represent different clusters, and each node's size reflects the number of occurrences of its corresponding keyword.
Figure 5A shows a keyword cluster map in the WoS database, comprising seven clusters generated based on keyword co-occurrence, coded as follows: Cluster 1, Building Information Modeling (BIM); Cluster 2, Construction Industry; Cluster 3, Lean Construction; Cluster 4, Project Governance; Cluster 5, Construction Management; Cluster 6, Agile Management; and Cluster 7, Construction Productivity. Cluster 3, Lean Construction, is the largest, exhibiting the highest total link strength (2492) and the highest number of occurrences (424). It includes keywords such as "lean construction," "implementation," "industry," and "sustainability." The co-location of "implementation" and "sustainability" within the dominant Lean Construction cluster suggests that research on lean in construction has increasingly emphasized adoption-related challenges and sustainability-oriented outcomes. In contrast, the appearance of "Agile Management" as a separate cluster indicates that agile-related research remains comparatively smaller and weaklier integrated with the mainstream lean-focused keyword structure within WoS.
Figure 5B presents six clusters in the Scopus database, also created based on keyword co-occurrence and coded as follows: Cluster 1, Building Information Modeling (BIM); Cluster 2, Lean Construction; Cluster 3, Project Management; Cluster 4, Lean Production; Cluster 5, Implementation Barriers; and Cluster 6, Production Control. Cluster 2, related to lean construction, is the most prominent, with the highest total link strength (4107) and the highest number of occurrences (659). It includes keywords such as "lean construction," "lean production," "construction industry," and "lean." The separation of "Sustainability" into its own cluster in Scopus, while still being closely connected to lean-related terms, suggests that sustainability has emerged as a substantial sub-field rather than a peripheral topic. Consistent with Table 7 and the WoS map, agile-related terms do not appear among the dominant Scopus clusters, reinforcing the interpretation that agile research remains less visible compared with lean construction in this domain.
Figure 5C presents six clusters in the merged database, constructed based on keyword co-occurrence, and coded as follows: Cluster 1, Construction Projects; Cluster 2, Lean Construction; Cluster 3, Project Management; Cluster 4, Production Control; Cluster 5, Building Information Modeling (BIM); and

Cluster 6, Safety Management. Cluster 2, Lean Construction, again appears as the largest cluster in terms of total link strength (4865) and number of occurrences (765). It includes keywords such as "lean construction," "lean production," "construction industry," and "lean." The strong linkage between "lean construction," "BIM," and "sustainability" indicates that current research increasingly treats digitalization and sustainability as intertwined enablers and outcomes of lean-oriented project delivery, rather than isolated themes. Meanwhile, the limited visibility of an agile-specific cluster in the merged map supports the interpretation that agile research remains comparatively fragmented or underrepresented within the broader construction management scientometric landscape. These thematic patterns—revealed more clearly in the merged dataset than in either database alone—reinforce the methodological value of dataset integration for capturing the field's dominant and emerging research streams.

Figures 6A–C show the overlay visualization maps for WoS, Scopus, and the merged dataset, respectively. The overlay visualization displays the temporal evolution of keywords in the network. In these maps, the color gradient represents the average publication year of each keyword: earlier research topics appear in blue-to-purple tones, whereas more recent topics appear in green-to-yellow tones. Accordingly, the overlay indicates a shift from earlier emphasis on foundational lean implementation and productivity-oriented terms toward more recent attention to themes such as BIM-enabled delivery, sustainability, and adoption/implementation challenges, reflecting the field's evolving priorities over time. The merged overlay (Figure 6C) offers the clearest temporal signal by reducing duplicate records and combining coverage, which helps reveal emerging themes that may appear delayed or less visible when relying on a single database.

3.6.1. Adoption-related issues synthesis (barriers/enablers/CSFs)

Implementation and "barriers" are among the high-frequency terms (Table 7) and are embedded within the dominant Lean Construction cluster across the maps (Figures 5A–C), indicating that adoption constraints are most frequently examined through lean-oriented studies rather than agile-focused publications. This keyword evidence further supports the study objective on adoption-related constructs. Further evidence that adoption/implementation issues have gained prominence in recent years, along with the growth of BIM and sustainability-related topics, is provided by the overlay visualizations (Figures 6A–C). These together indicate a shift toward practice-oriented research questions on "how" lean (and, to a lesser extent, agile) can be deployed effectively in construction contexts.

3.6.2. Thematic Synthesis of Keyword and Cluster Evidence

To synthesize the keyword frequencies, co-occurrence patterns, cluster structures, and overlay visualization results, the evidence was organized into field-level thematic directions. These directions were derived primarily from the merged dataset, which serves as the main interpretive basis of the study, while the WoS-only and Scopus-only maps were used to identify database-specific variation. Table 6 summarizes the main thematic directions emerging from the keyword and cluster eviden

Table 6. Thematic synthesis of keyword and cluster evidence

Thematic direction	Scientometric evidence	Analytical interpretation
Lean-centered process improvement	In the merged dataset, “lean construction” is the most frequent keyword, with 219 occurrences and 1183 total link strength. It also appears as the largest cluster in the merged keyword map, with the highest total link strength and occurrence values.	This indicates that the conceptual structure of the field is primarily organized around lean-oriented process improvement, value delivery, and construction productivity themes. Lean construction therefore represents the dominant and most consolidated research stream in mapped literature.
Construction project management core	“Construction industry”, “project management”, “lean production”, “construction projects”, and “construction management” are among the most frequent keywords in the merged dataset.	These terms show that the field is anchored in construction management and project delivery concerns rather than in a purely theoretical lean/agile debate. The mapped literature is therefore closely connected to practical project delivery problems.
BIM and digitalization-supported delivery	BIM and building information modelling appear among the frequent keywords and relate to lean-related terms in the keyword maps. The merged map shows links among lean construction, BIM, and sustainability.	BIM appears as a bridging theme that connects process improvement, information flow, coordination, and digital project delivery. This suggests that digitalization is increasingly discussed alongside lean-oriented construction management.
Adoption and implementation issues	“Implementation” and “barriers” are among the high-frequency terms and are embedded within the dominant Lean Construction cluster across the keyword maps.	Adoption-related issues represent a recurring practice-oriented stream in literature. This supports the study’s focus on drivers, enablers, barriers, challenges, and critical success factors as literature-framing constructs rather than validated causal variables.
Sustainability-oriented research direction	“Sustainability” appears among the frequent keywords in the merged dataset and is linked with lean construction and BIM-related themes. Overlay visualizations indicate increasing attention to sustainability, BIM-enabled delivery, and implementation challenges.	Sustainability is interpreted as an emerging thematic direction in the mapped literature. Within this scientometric study, this indicates thematic visibility and conceptual linkage, not direct measurement of sustainability outcomes.
Limited consolidation of agile research	Explicit agile-related terms do not appear among the top twenty keywords in the merged list, and no dominant agile-specific cluster appears in the merged keyword map.	Agile project management appears less visible and less consolidated than lean construction in the current construction management literature. This does not imply that agile is irrelevant, but rather that agile-oriented research remains comparatively fragmented and requires further targeted synthesis.
Integrated emerging agenda	The merged keyword map shows linkages among lean construction, project management, BIM, sustainability, and implementation-related issues.	The mapped literature appears to be moving toward an integrated construction management agenda that connects process improvement, digitalization, sustainability, and adoption challenges. This synthesis explains the thematic evolution of the field beyond isolated keyword occurrences.

Overall, this synthesis indicates that the field is structured around a dominant lean-centered process improvement stream, supported by project management, BIM/digitalization, adoption-related, and sustainability-oriented themes. At the same time, agile project management remains less consolidated within the mapped literature. The keyword evidence therefore suggests that the field is evolving from a narrow focus on lean implementation and productivity toward a broader construction management agenda involving digitalization, sustainability, and implementation conditions.

3.7. Citation Network

The objective of the citation analysis was to identify the principal research documents and sources. Identifying document citations and citation clusters facilitates the examination of highly cited works and underscores crucial research domains.

The citation analysis indicated that the citation threshold was set at 20; in WoS, 129 out of 283 articles met the criteria; in Scopus, 129 out of 323 publications met the criteria; and in the merged database, 186 out of 411 publications met the criteria. The clusters and links are as follows: WoS (49 clusters, 194 links), Scopus (129 clusters, 0 links), and the merged database (184 clusters, 2 links). Figure 7 illustrates the citation analysis network, where larger circles indicate greater citation counts.

Within the chosen thresholded set, the extremely sparse link structure—especially in Scopus (0 links) and the combined dataset (2 links)—indicates that important articles constitute a scattered intellectual base with little direct citation connectedness. To comprehend the intellectual base through the most prominent texts and their predominant thematic emphasis (such as the benefits of BIM, delays, green construction, and lean implementation), Table 8 is utilized in conjunction with Figure 7.

Table 7. Most frequent keywords in WOS, Scopus, and merged database.

WoS			Scopus			Merged		
Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
Lean construction	124	580	Lean construction	200	1048	Lean construction	219	1183
Management	71	382	Construction industry	172	1049	Construction industry	182	1143
Implementation	65	404	Lean production	102	780	Project management	109	748
Performance	58	326	Project management	101	677	Lean production	99	782
Barriers	47	291	Construction	57	421	Construction projects	82	468
Construction industry	40	225	Construction projects	55	354	Construction	67	486
Model	39	190	Construction management	31	192	Sustainability	34	204
Framework	37	207	Architectural design	29	279	Construction management	33	217
Construction projects	36	153	Surveys	28	238	Barriers	33	176
Design	32	160	Building information modelling	27	247	Performance	32	177
Construction	30	133	Sustainability	25	148	Architectural design	29	287
Sustainability	29	164	Bim	23	143	Bim	28	174
Industry	26	159	Last planner system	23	124	Building information modelling	27	256
Bim	26	142	Productivity	21	127	Surveys	27	236
Projects	24	149	Lean	21	106	Management	27	142
Project management	23	117	Design/methodology/approach	20	176	Implementation	24	158
Impact	22	133	Sustainable development	20	158	Productivity	24	140
Thinking	20	171	Barriers	20	101	Framework	23	142
Integration	20	105	Building information modeling	16	142	Last planner system	23	131
Construction management	٢٠	٨٨	Information theory	13	147	Lean	21	120

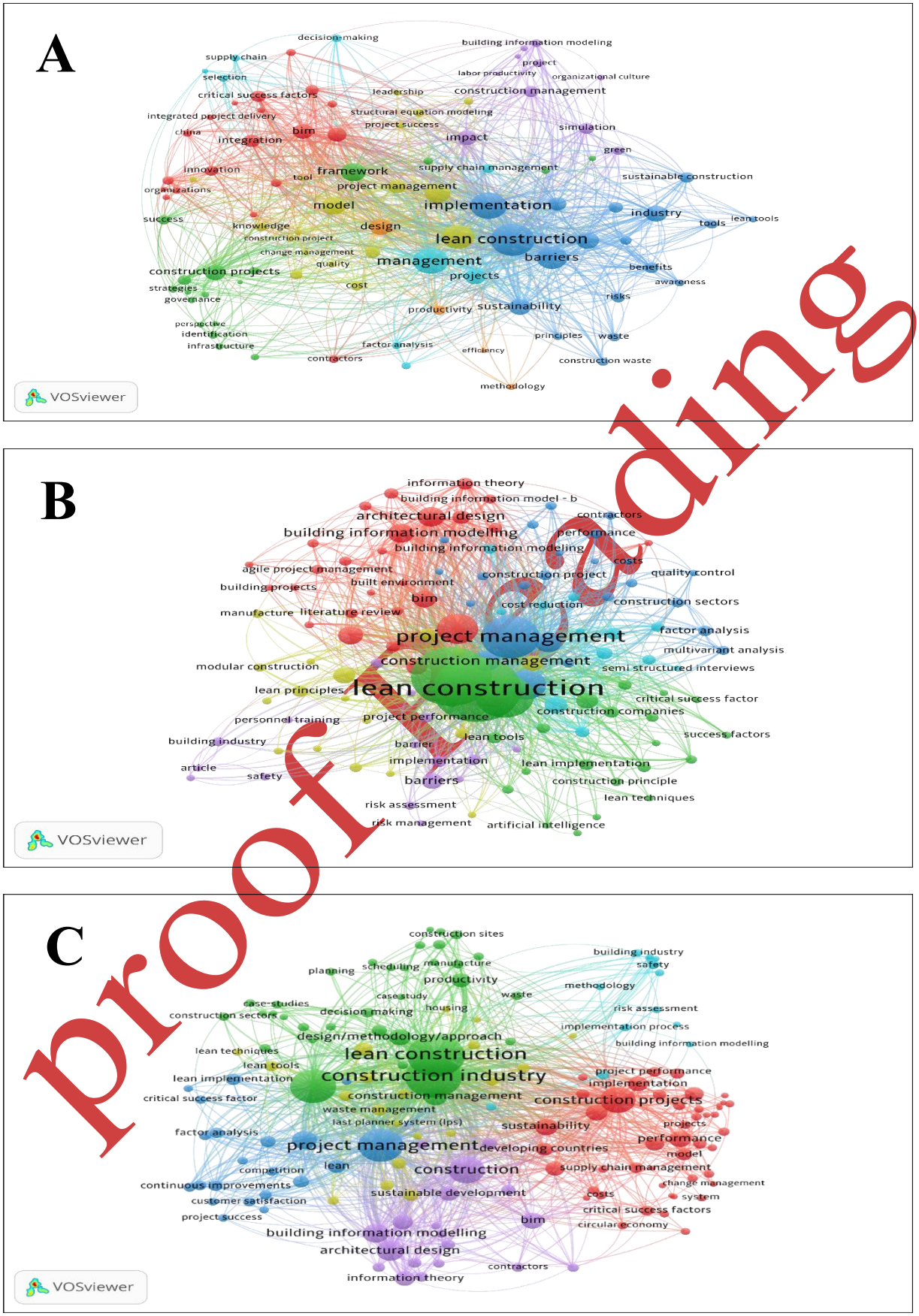


Figure 5. Keyword Co-occurrences in: (A) WoS database. (B) Scopus database. (C) Merged database.

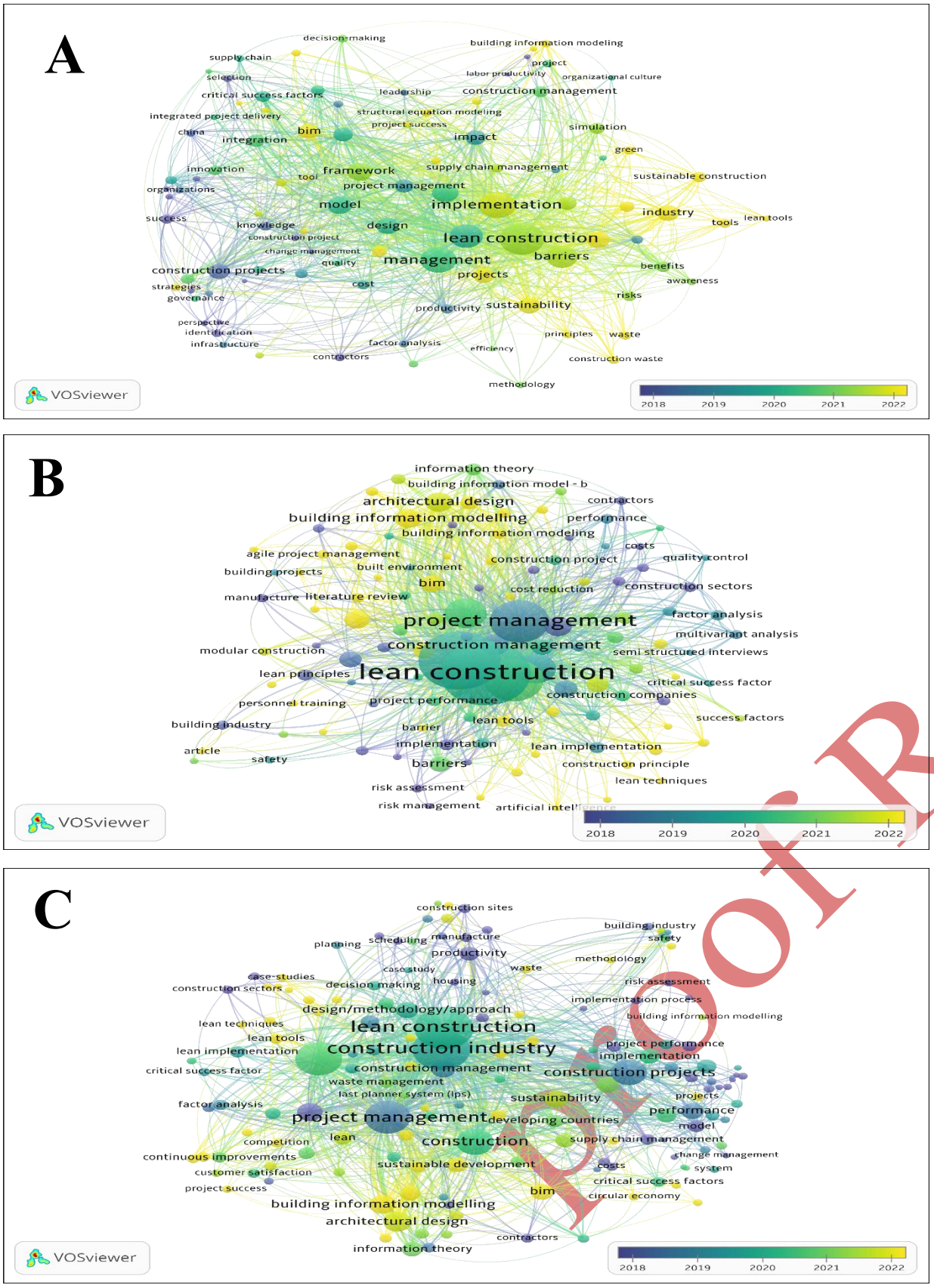


Figure 6. The evolution of keyword Co-occurrence network in: (A) WoS database. (B) Scopus database. (C) Merged database.

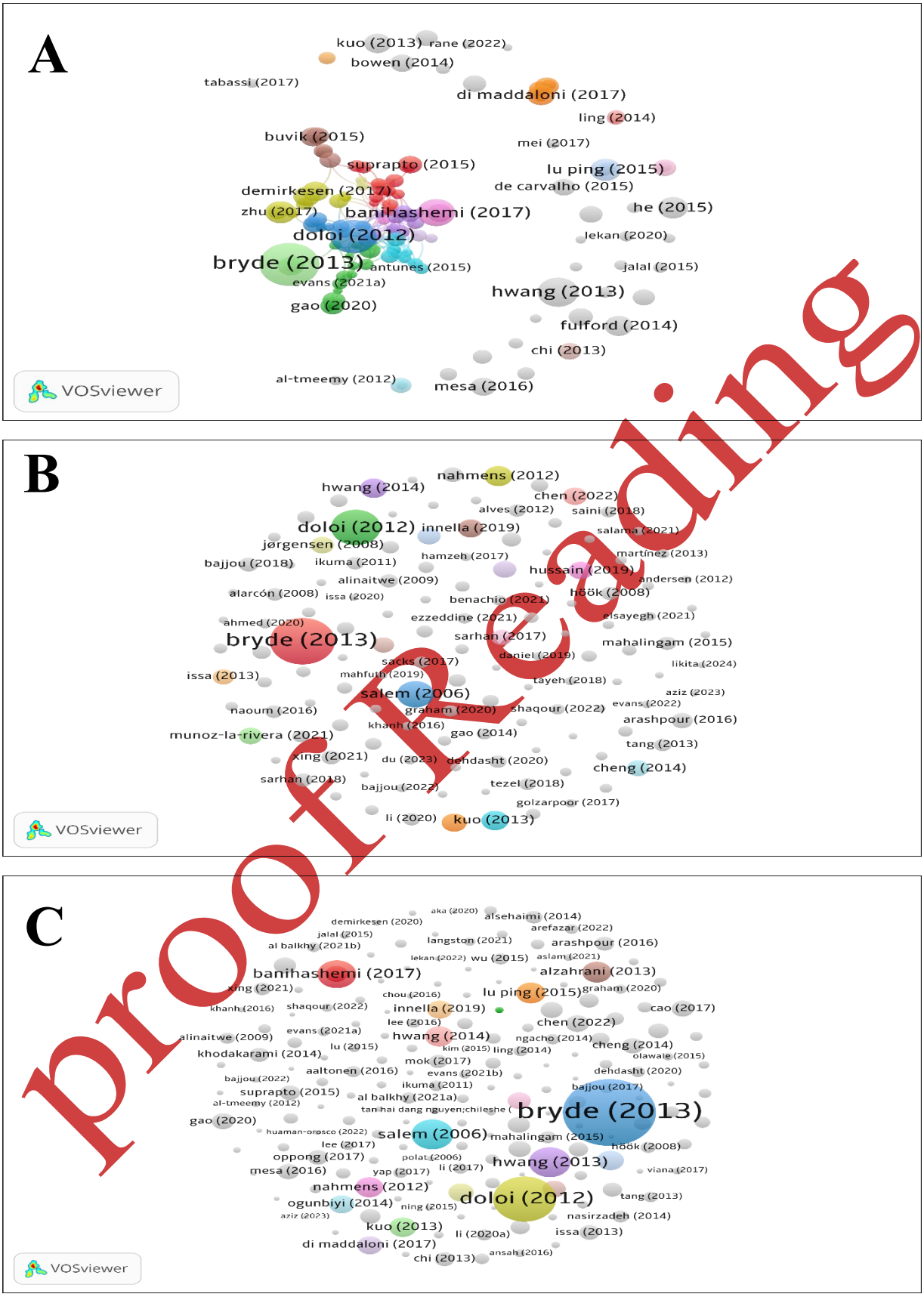


Figure 7. Document as a unit of citation analysis in: (A) WoS database. (B) Scopus database. (C) Merged database.

Table 8. Most influential papers in Scopus, WoS, and merged database.

Scopus			
Author	Publication title and reference	Journal	Citations
Bryde et al. (2013)	The project benefits of building information modelling (BIM)	International Journal of Project Management	1005
Doloi et al. (2012)	Analysing factors affecting delays in Indian construction projects	International Journal of Project Management	582
Salem et al. (2006)	Lean construction: From theory to implementation	Journal of Management in Engineering	321
Nahmens and Ikuma (2012a)	Effects of lean construction on sustainability of modular homebuilding	Journal of Architectural Engineering	186
Hwang et al. (2014)	Risk management in small construction projects in Singapore: Status, barriers and impact	International Journal of Project Management	184
Kuo and Lu (2013)	Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects	International Journal of Project Management	179
Ogunbiyi et al. (2014)	An empirical study of the impact of lean construction techniques on sustainable construction in the UK	Construction Innovation	159
Innella et al. (2019)	Lean methodologies and techniques for modular construction: Chronological and critical review	Journal of Construction Engineering and Management	158
Hussain et al. (2019)	Green, lean, six sigma barriers at a glance: A case from the construction sector of Pakistan	Building and Environment	144
Chen et al. (2022)	Revamping construction supply chain processes with circular economy strategies: A systematic literature review	Journal of Cleaner Production	140
WoS			
Bryde et al. (2013)	The project benefits of building information modelling (BIM)	International Journal of Project Management	744
Doloi et al. (2012)	Analysing factors affecting delays in Indian construction projects	International Journal of Project Management	434
Hwang and Ng (2013)	Project management knowledge and skills for green construction: Overcoming challenges	International Journal of Project Management	327
Banihashemi et al. (2017)	Critical success factors (CSFS) for integration of sustainability into construction project management practices in developing countries	International Journal of Project Management	289
Lu et al. (2015)	The effectiveness of contractual and relational governances in construction projects in China	International Journal of Project Management	196
Alzahrani and Emsley (2013)	The impact of contractors' attributes on construction project success: A post construction evaluation	International Journal of Project Management	195
He et al. (2015)	Measuring the complexity of mega construction projects in China—A fuzzy analytic network process analysis	International Journal of Project Management	176
Fulford and Standing (2014)	Construction industry productivity and the potential for collaborative practice	International Journal of Project Management	162
Di Maddaloni and Davis (2017)	The Influence of Local community stakeholders in megaprojects: Rethinking their inclusiveness to improve project performance	International Journal of Project Management	161
Kuo and Lu (2013)	Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects	International Journal of Project Management	152
Merged			
Bryde et al. (2013)	The project benefits of building information modelling (BIM)	International Journal of Project Management	1005

Doloi et al. (2012)	Analysing factors affecting delays in Indian construction projects	International Journal of Project Management	582
Hwang and Ng (2013)	Project management knowledge and skills for green construction: Overcoming challenges	International Journal of Project Management	327
Salem et al. (2006)	Lean construction: From theory to implementation	Journal of Management in Engineering	321
Banihashemi et al. (2017)	Critical success factors (CSFS) for integration of sustainability into construction project management practices in developing countries	International Journal of Project Management	289
Lu et al. (2015)	The effectiveness of contractual and relational governances in construction projects in China	International Journal of Project Management	196
Alzahrani and Emsley (2013)	The impact of contractors' attributes on construction project success: A post construction evaluation	International Journal of Project Management	195
Nahmens and Ikuma (2012a)	Effects of lean construction on sustainability of modular homebuilding	Journal of Architectural Engineering	186
Hwang et al. (2014)	Risk management in small construction projects in Singapore: Status, barriers and impact	International Journal of Project Management	184
Kuo and Lu (2013)	Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects	International Journal of Project Management	179

3.8. Most influential papers

The most influential research papers are shown in Table 8. The list was compiled based on the most cited publications in Scopus, WoS, and the merged database. **Bryde et al. (2013)** have the highest citation count in the merged database, with 1005 citations, for their paper titled "The Project Benefits of Building Information Modelling (BIM)," published in the International Journal of Project Management. The second and third most cited papers in the merged database are **Doloi et al. (2012)**, "Analysing Factors Affecting Delays in Indian Construction Projects," published in the International Journal of Project Management with 582 citations, and **Hwang and Ng (2013)**, "Project Management Knowledge and Skills for Green Construction: Overcoming Challenges," also in the International Journal of Project Management, with 327 citations. Regarding the WoS and Scopus databases, the first and second rankings are identical to those in the merged database. In WoS, the third position is held by **Hwang and Ng (2013)**, "Project management knowledge and skills for green construction: Overcoming challenges," published in the International Journal of Project Management, whereas in Scopus, it is held by **Salem et al. (2006)**, "Lean construction: From theory to implementation," published in the Journal of Management in Engineering. Together with fundamental lean construction implementation research, the most referenced publications in the combined dataset often centre on three main knowledge streams: schedule/time-performance issues (such as delays), sustainability/green construction capabilities, and the advantages of BIM-enabled projects. The top-ranked influential articles in Table 8 do not include any publications that are specifically about agile, which is noteworthy and supports the keyword evidence that agile is still less visible and integrated than lean construction in the field's mainstream intellectual foundation.

It was also noted that the top 10 most cited articles in WoS were all published in the same journal, the "International Journal of Project Management". At the same time, Scopus showed a variety of journals, including the "International Journal of Project Management", the "Journal of Management in Engineering", and the "Journal of Architectural Engineering", among others.

After merging the databases, the most-cited articles in the merged database appeared in the "International Journal of Project Management", except for two articles in the "Journal of Architectural Engineering", and the "Journal of Management in Engineering". Overall, the integrated approach preserves important

papers from complementary channels that may be underrepresented if depending on a single database, while also confirming the International Journal of Project Management's fundamental significance in the intellectual foundation of this study topic.

4. DISCUSSION

The discussion is guided by the conceptual framework developed in this study. The identified clusters are interpreted as thematic indicators of the field structure, showing how lean-oriented efficiency, agile-oriented adaptability, adoption-related issues, and sustainability-oriented themes are positioned within construction management research.

In contrast to using a single index, the merged dataset has 411 unique records, whereas the unmerged total had 606 records (323 + 283). This indicates significant overlap that would otherwise inflate counts and influence rankings. The results show that combining the two databases creates a clearer and less biased map of the field. These discrepancies across WoS, Scopus, and the merged dataset confirm that reliance on a single database may distort the observed scientometric landscape; therefore, the merged and de-duplicated dataset provides the most appropriate basis for integrated interpretation in this study.

Geographically, the United States, the United Kingdom, and China continue to dominate the publication landscape, and collaboration maps depict these nations as key hubs within global networks, indicating that productivity and influence are still concentrated in a small number of research economies. However, the inclusion of more nations in the combined dataset (as opposed to only one database) implies that database integration raises awareness of more extensive involvement and cooperative relationships that can be overlooked when utilizing a single index.

Consistent with the thematic synthesis in Table 6, the dominance of lean-related terms indicates that lean construction is the most mature and consolidated research stream in the mapped literature. This reflects the long-standing use of lean concepts to address process improvement, value delivery, waste reduction, and implementation challenges in construction projects. By contrast, the weaker visibility of agile-related terms suggests that agile project management remains less consolidated within construction management research. This does not mean that agile is irrelevant; rather, it shows that agile applications in construction are still emerging and require further conceptual and empirical development.

The links among lean construction, BIM, sustainability, and implementation-related terms indicate a broader thematic shift in the literature. The mapped field appears to be moving from a narrow focus on lean implementation and productivity toward a wider research agenda that connects process improvement with digital coordination, sustainability-oriented thinking, and adoption challenges. Accordingly, the clusters and trends provide evidence of the field's thematic evolution and help explain how lean/agile construction research is developing beyond isolated implementation and productivity concerns.

The list of the most influential publications and the citation analysis help to further elucidate the intellectual foundation of the field. The evidence suggests that the intellectual core of this domain is anchored in project management and construction engineering concerns rather than in a purely "lean-only" or "agile-only" stream because highly cited works in the merged dataset converge around BIM-enabled project benefits, schedule/time-performance issues (such as delays), sustainability/green construction capabilities, and foundational lean construction implementation research. The interdisciplinary nature of the field is further supported by the distribution of prominent publications across journals, which indicates that although a large project-management outlet plays a crucial role, influential contributions are spread across complementary engineering-oriented venues. The combined evidence suggests that lean construction is currently the most prevalent organizational paradigm in the mapped construction management literature, whereas agile remains a relatively emerging and fragmented stream.

Future research has a clear opportunity to improve conceptual integration, define boundary conditions for when agile practices are useful in the construction industry (such as stakeholder coordination intensity, governance structures, and uncertainty profiles), and examine how agile practices relate to well-established lean principles.

Practically speaking, the close relationship between lean, BIM, and sustainability raises the possibility that businesses looking to boost performance will increasingly view digitalization and sustainability as complementary levers inside lean implementation projects rather than as distinct endeavors.

More specifically, the merged-map pattern suggests sustainability implications that align with priorities already highlighted in the cited construction literature, including environmentally oriented lean implementation, lean–BIM integration, circular-economy-oriented delivery, and sustainable residential/building applications.
Furthermore, the recurring focus on implementation and barriers suggests that organizational and stakeholder factors may be as important to adoption success as technical tool selection. This emphasizes the necessity of implementation roadmaps, capability building, and governance mechanisms that promote long-term use.

Taken together, the present findings provide a direct narrative response to the study objectives: RQ1 is addressed by showing the post-2015 acceleration of publication activity and the concentration of influential output in core project-management and construction journals and countries, RQ2 is addressed by showing that the merged Scopus–WoS dataset provides a more stable and less biased representation of rankings, collaboration patterns, and thematic signals than single-database views, and RQ3 is addressed by showing that lean-oriented research dominates the field while BIM, sustainability, and adoption-related terms form an emerging integrated thematic stream, whereas agile remains smaller and less consolidated. These results imply that construction-management research should further clarify the conditions under which agile complements mainstream lean-oriented practice, while also expanding targeted syntheses on digitally enabled, sustainability-oriented, and implementation-focused project delivery. For practice, the recurring prominence of implementation barriers, BIM, and sustainability suggests that performance improvement in construction is likely to depend not only on selecting lean/agile tools, but also on capability building, governance alignment, and staged implementation roadmaps that support long-term adoption.

5. Conclusions

The construction sector often faces delays, budget overruns, and difficulties in meeting quality standards. Despite the application of innovative technologies in construction projects, the sector's efficiency remains below expectations. As projects become increasingly complex, the need for creative approaches to enhance productivity and value creation is becoming more apparent. This study conducts an integrated bibliometric analysis of agile and lean research in the construction sector, examining citation patterns, authors, countries, journals, and key emerging research topics. To strengthen coverage and reduce single-database bias, records from Scopus and WoS were merged and de-duplicated to form a unified dataset used as the primary basis for interpretation. Bibliometric analysis is particularly useful in its ability to track the field's historical development and uncover new research trends and issues. The study demonstrates that research on agile and lean construction has grown significantly. The merged evidence indicates that publication activity accelerates notably after 2015 and reaches its highest level in 2024. Theoretically, the study identifies key research areas and emerging trends in agile and lean construction research within the construction sector. Agile-oriented research is still very modest and less evident in the key theme frameworks, but lean construction is the field's leading knowledge stream overall. Lean construction, project management, and construction management are the areas of most significant focus. Building Information Modeling (BIM)-based approaches, architectural design and information modeling, and sustainability-focused studies are emerging areas in agile and lean construction research that address known knowledge gaps. Along with recurrent implementation-related phrases (e.g., barriers/implementation) that represent how adoption issues are framed in the literature at the corpus level, keyword co-occurrence structures also show strong connections between lean construction, BIM, and sustainability topics. Crucially, rather than being exposed through manual content coding, adoption-related constructs are surfaced through query words and keyword-network evidence; as a result, the findings map prominence and theme linkages rather than offering a proven causal factor model. The agile and lean construction studies were limited to construction projects only. The publications considered in this study were those indexed only in Scopus (323 publications) and WoS (283 publications). Network results are dependent on the selected thresholds and the citation window, and only English-language journal articles and reviews published between 2005, and October 2025 were included. Despite these limitations, the findings contribute significantly to future agile and lean studies and practices in the construction industry. To improve integration with the mainstream lean-oriented stream and elucidate adoption conditions, future research can expand this mapping through deeper agile-focused syntheses and targeted content analysis.

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