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Uncovering Barriers to Circular Construction: A Global Scientometric Review and Future Research Agenda

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Abstract: The construction industry is critical to economic growth and environmental sustainability. However, its substantial resource consumption and waste generation highlight the urgent need for a transition toward circular construction (CC) practices. This study uses scientometric and content analyses of 199 articles published between 2017 and 2024 to uncover the barriers to adopting CC principles. This study aims to identify these barriers, map key research trends, and propose future directions for addressing obstacles to CC adoption. This research focuses on global contributions to CC, highlighting influential nations, journals, and scholars and analyzing keyword trends over time. Additionally, it examines the recurring themes and patterns to provide a holistic understanding of the systemic challenges faced by the construction industry in embracing CC principles. By presenting the first comprehensive overview of barriers to CC, this study fills a critical research gap and offers insights for researchers and policymakers. The findings reveal that 12% of the total publications in the field originate from Australia and China, leading in contributions, while journals such as *Sustainability* and the *Journal of Cleaner Production* account for 31.5% of the articles. Keyword co-occurrence analysis identifies "management", "barriers", and "waste management" as prevailing themes. The annual growth rate of CC-related publications is 44.78%, underscoring its rising importance. Furthermore, 41 barriers to CC were revealed with content analysis. These insights offer a foundational understanding for policymakers and researchers, emphasizing collaboration, government intervention, and innovation in materials and technology to overcome barriers and transition to a circular, resource-efficient construction model.

Keywords: circular construction; circular economy; barriers; scientometric analysis; content analysis; RStudio

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1. Introduction

The construction industry is pivotal in terms of economic growth and environmental impact [1]. In the European Union (EU), this sector contributes approximately 9% of the gross domestic product (GDP) while providing substantial employment opportunities, with 18 million direct jobs [2,3]. Beyond its economic contributions, the construction industry fulfills essential societal needs by delivering buildings and infrastructure. However, it is a significant consumer of resources, utilizing nearly half of all raw materials and accounting for 36% of global energy consumption [4,5]. Additionally, the construction sector is responsible for 39% of energy-related emissions and other pollutants that contribute to acid rain. If these greenhouse gas emissions persist at current levels, they will exacerbate environmental challenges [4,6]. Measures addressing climate change and promoting cleaner production must prioritize the construction sector [7,8].

Beyond its environmental impacts, construction and demolition activities are responsible for approximately one-third of the total waste generated in the EU, with a significant portion ending up in landfills. This leads to severe environmental issues throughout the entire lifecycle of buildings, particularly during their operational and end-of-life phases [9]. Furthermore, current population growth trends suggest that the global middle class will double from two billion to over four billion by 2030 [10]. As a result, the need for urban development will surpass what has been built over the past 4000 years to accommodate future well-being and progress [11]. Another critical challenge is the rising cost of raw materials, which drives the construction industry to explore more efficient resource alternatives, such as material reuse and recycling [11,12]. Given these challenges, there is growing urgency for the construction sector to transition to a more sustainable model, emphasizing the adoption of circular economy (CE) principles to create a more environmentally friendly building industry [13–15].

The core CE principles of reducing, reusing, and recycling materials and components (the 3Rs) have been successfully applied in various industries, such as electronics, furniture, and textiles. However, their implementation in the construction sector is more recent and less widespread, primarily focusing on waste prevention and material management, emphasizing recycling [16–19]. The construction industry is recognized as one of the three sectors with significant potential for CE strategy adoption, mainly through environmentally friendly products and technologies [20,21]. Applying CE principles in construction encourages sustainable materials, enhances material recovery, and minimizes waste generation and landfill disposal [22–24]. It is estimated that integrating CE practices into the built environment in Europe could lead to resource and energy savings worth EUR 350 billion by 2030 [25].

Nevertheless, the construction sector faces challenges due to its deeply entrenched project-based practices and market mechanisms, which often hinder the integration of CE principles [11]. Building projects involve numerous stakeholders within a complex supply chain, each contributing to the environmental impact and overall cost of production [11,26,27]. Given these complexities, government intervention through clear guidelines and policies is essential to support the construction sector's transition toward a CE [28].

Converging CE principles and circular construction (CC) is crucial in promoting sustainability. CE emphasizes the preservation of the value of materials and resources throughout their lifecycle, which is particularly significant in the construction sector due to its high levels of waste and resource use [29]. CC specifically applies CE concepts within the construction industry, focusing on strategies like designing buildings for disassembly, material reuse, and waste recycling [11,30,31]. As highlighted earlier, construction significantly contributes to global waste, making integrating CE practices essential for environmental improvements, such as lowering carbon emissions and reducing landfill waste [32]. Examples of CE strategies, such as modular construction and recycled materials, have demonstrated their potential to increase resource efficiency and encourage sustainable practices within construction projects [33].

CC addresses the entire lifecycle of construction projects—including planning, design, construction, operation, and deconstruction—through a sustainability-driven framework [34]. This approach optimizes resource use, minimizes waste, and promotes the continuous reuse of materials within closed-loop systems to maintain their highest value [35–38]. CC reduces environmental impacts and delivers significant economic and social benefits, supporting the sustainable execution of construction projects.

Key benefits of CC include waste reduction, the conservation of renewable resources, and enhanced material circularity [39,40]. It also fosters innovation throughout the supply chain, enabling projects to be designed for durability, repairability, and eventual reuse [41,42]. However, implementing CC introduces new complexities and uncertainties in project delivery, highlighting the need for focused research [39,43,44].

The existing literature has explored various dimensions of CC, including waste management [14,45–49], the integration of CE principles [50–52], the adoption of CE in the construction industry [53–55], performance indicators [56–60], and stakeholder-related barriers [61–64]. These studies underscore the opportunities and challenges of advancing CC, particularly as the construction sector navigates the transition toward more circular and sustainable practices.

A brief review highlights several concepts for implementing CC, including challenges, design limitations, and integrating modern and digital technologies. The growing emphasis on CC has generated significant scholarly discourse and research contributions across various academic platforms. As the construction industry evolves in response to sustainability challenges, understanding the trajectory of intellectual engagement is crucial to comprehending the complex barriers hindering the holistic adoption of circular practices. This ongoing exploration highlights the need for deeper insight into the systemic obstacles shaping the future of CC. Within this scope, the contribution and importance of review studies cannot be overstated [65]. When the literature is analyzed in this regard, several review studies on CE in the construction industry or CC are present (e.g., Mrad and Ribeiro [66]; Munarao and Tavares [67]; Yu et al. [68,69]; Wuni [70]; Lei et al. [71]); these authors performed their reviews qualitatively or focused on specific subjects such as the critical success factors of implementing CC or barriers to CC from a limited stakeholder perspective.

In contrast, there are also quantitative review studies related to CE in the built environment (e.g., Antwi-Afari et al. [60]; Osobajo et al. [72]; Zhang et al. [73]; Norouzi et al. [74]). Although these studies contribute valuable insights into understanding the CC circularity gap, they could also have holistically presented the barriers to CC. In other words, a significant research gap still needs to be addressed.

This study aims to uncover the gaps in the literature mentioned above and respond to the significant barriers to CC (B2CC) by conducting scientometric and content analyses. To bridge these gaps, this study aims to perform a science mapping-based review of the existing literature's barriers to CC, exploring key research themes, identifying gaps, and suggesting future research directions. The research questions developed to guide the research were as follows:

RQ_1: What patterns are observed in the annual distribution of articles and citations on barriers to CC, and in what ways do these patterns enhance the field of B2CC?

RQ_2: Which nations are the leading contributors to research on B2CC?

RQ_3: Which academic journals make substantial contributions to the study of B2CC?

RQ_4: Which scholars make substantial contributions to the study of B2CC?

RQ_5: What is the relationship among the key terms?

RQ_6: What temporal trends can be identified by analyzing keywords in B2CC across different periods?

RQ_7: What are the prevailing themes and patterns identified in the literature regarding B2CC?

RQ_8: What are the main barriers hindering CC holistically?

RQ_9: What are the future directions of B2CC?

This study offers a novel contribution by presenting the first comprehensive overview of barriers to circularity in global construction and the built environment. It expands the knowledge base needed for implementing circular economy principles in the construction sector by identifying key global trends and viable future research directions. The findings and recommendations are expected to aid circularity researchers and policymakers in aligning with the existing circular economy framework and shaping future policy developments.

2. Comprehensive Review of Circular Construction Literature

The construction industry is a significant consumer of natural resources, and the inefficient use of non-renewable materials can lead to resource depletion [61,75]. CE has emerged as a sustainable solution, highlighting the urgent need to mitigate the industry's environmental impacts [16].

To address these challenges, scholars have explored key barriers to CE implementation in construction and various strategies for a smooth transition to CC [28,67,71,72]. In parallel, the integration of technologies like information communication technologies (ICT), artificial intelligence (AI), blockchain, the Internet of Things (IoT), and Construction 4.0 tools into CC practices has been examined to promote sustainability in the built environment [69,76,77]. Particular attention has been given to the adoption of building information modeling (BIM) in CC, which is currently a focus of global discussion for its potential to enhance circularity through the use of sustainable materials [78,79]. While BIM integration has been a primary focus, other studies have delved into specific aspects of CC, including construction management within the CE framework [80], defining CE dimensions [17], and categorizing industry-specific concepts [81]. Additionally, previous research has addressed circularity indicators [82], the CE potential of construction waste [83], and weaknesses in CC practices [42,84].

The effectiveness of CC approaches is also shaped by the demographic and developmental levels of the countries where it operates [85]. In developed regions like the EU, comprehensive CC strategies have been adopted, focusing on CE principles [66], circularity regulation [86], and construction and demolition waste management [87].

Localized approaches have been explored at the national level, particularly in the UK, the Netherlands, and Japan, emphasizing CE awareness and strategic initiatives [79,88–90].

Conversely, in developing countries, various aspects of CC have been explored, with a focus on identifying barriers to a CE [91], proposing practical frameworks [92], and examining the impact of technologies on CE performance [54]. These contrasting strategies underscore the fundamental differences between developed and developing countries in their approach to CC, with developed nations emphasizing comprehensive strategies and developing countries focusing on localized, barrier-specific solutions.

Various methodologies have been employed to tackle these challenges, reflecting the evolving nature of CC research. Chief among these are online questionnaires and quantitative data analysis [93–97]. Other studies have utilized factor analysis [53,98–100], the analytic hierarchy process [101], Monte Carlo simulations [52], the DEMATEL method [102,103], and the one-way ANOVA [75,94,104,105]. Qualitative and mixed methods have also been employed, including semi-structured interviews [106,107], case studies [51,108], SWOT analysis [96], Pareto analysis [40,70,109–111], and focus group interviews [55,112]. These diverse methodological approaches collectively contribute to a more nuanced understanding of CC and reveal the complexities that further research must address.

Despite these advancements, the nascent stage of CC highlights the need for continued exploration of all its aspects. As Oluleye et al. [77] and Mrad and Frölén Ribeiro [66] indicate, this gap in the literature calls for review methods, including scientometric analysis. Despite significant research, consensus on key CC aspects is lacking, underscoring the need for comprehensive reviews. These methods, alongside qualitative studies, are crucial for gaining a deeper understanding of its scope, as detailed in Table 1.

Table 1. Summary of review studies on circular construction.

Study	Focus of the Study	Scope	Database	Period	Type of Research	Main Method	Software Tool	Type of Literature Review
[113]	Barriers preventing CE implementation and advanced CDW management in the construction sector	54	ScienceDirect, Scopus	2013–2022	Not Bibliometric	Systematic Literature Review, PESTLE Analysis	-	Qualitative
[114]	Factors that could influence the adoption of the CE in the construction and demolition sector	53	Scopus, Web of Science	2003–2018	Not Bibliometric	Systematic Literature Review	-	Qualitative
[115]	Critical risk factors for CC projects	44	Scopus	2009–2022	Not Bibliometric	Systematic Literature Review, Mean Score, Pareto Analysis	-	Qualitative
[116]	Challenges in assessing CE for the built environment	42	Scopus, Web of Science	2010–2021	Not Bibliometric	Literature Review, Descriptive Analysis, Content Analysis	-	Qualitative
[117]	Categorization of CE interventions	19	Scopus	-	Not Bibliometric	Literature Review, Expert Interviews,	-	Qualitative
[118]	CE implementation in CDW management	212	Scopus, Web of Science, EBSCO	2017–2024	Bibliometric	Scientometric Analysis, Critical Analysis	VOSviewer	Mix
[119]	Strategies, challenges, and gaps of CE in the management of CDW.	116	Scopus	2014–2021	Bibliometric	Scientometric Analysis, Content Analysis	VOSviewer	Mix
[71]	Applications of life cycle assessment in CE for the built environment.	-	ScienceDirect, Scopus, Google Scholar	-	Not Bibliometric	Literature Review	-	Qualitative
[120]	CE practices and their relationships throughout the life cycle of a construction project	29	Scopus, Web of Science	2003–2023	Bibliometric	Systematic Literature Review, Bibliometric Analysis, Descriptive Analysis, Content Analysis	VOSviewer	Mix

Table 1. *Cont.*

Study	Focus of the Study	Scope	Database	Period	Type of Research	Main Method	Software Tool	Type of Literature Review
[121]	Business models to achieve sustainable buildings	89	Web of Science, Science Direct, Scopus	2006–2019	Not Bibliometric	Systematic Literature Review (Descriptive Analysis, Categorized Analysis)	-	Qualitative
[122]	Trends and patterns in CE research applied to CDW	1440	Web of Science, Scopus	1993–2020	Bibliometric	Double Integrated Analysis, Systematic Literature Review, Bibliometric Analysis	SciMAT	Mix
[123]	Current research trends and gaps on stakeholder collaboration towards a circular built environment	119	Scopus, Web of Science	2011–2021	Bibliometric	Systematic Literature Review, Bibliometric Analysis, Content Analysis	-	Mix
[60]	Key themes and gaps of CE	486	Scopus	All Years Till Present	Bibliometric	Scientometric Analysis, Content Analysis, Swot Analysis,	VOSviewer	Mix
[124]	Levels of circularity in the construction industry	1941	Web of Science, Scopus	All Years Till 2022	Bibliometric	Scientometric Analysis, Descriptive Analysis, Content Analysis	VOSviewer	Mix
[57]	Circularity and circularity indicators in the construction sector	1117	Web of Science	1970–2022	Bibliometric	Literature Review, Scientometric Analysis	VOSviewer	Mix
[109]	Barriers to adopting digital technology-enabled CE in the construction sector	28	Web of Science, Scopus	2019–2024	Bibliometric	Systematic Literature Review, Bibliometric Analysis, Pareto Analysis, Frequency Analysis, Content Analysis	VOSviewer	Mix
[125]	Barriers inhibiting CE uptake in the construction industry	48	Scopus	2006–2021	Bibliometric	Scientometric Analysis, Content Analysis	VOSviewer	Mix

Table 1. *Cont.*

Study	Focus of the Study	Scope	Database	Period	Type of Research	Main Method	Software Tool	Type of Literature Review
[126]	BIM integrated life cycle assessment (LCA) and CE adoption	74	Web of Science, ScienceDirect, Google Scholar	2000–2020	Bibliometric	Systematic Review, Scientometric Analysis	VOSviewer	Quantitative
[73]	Relationship between space and the CE in the built environment	218	Scopus	2000–2021	Bibliometric	Correlation Analysis, Systematic Literature Review	VOSviewer	Mix
[127]	Advancements for the application of CE principles in buildings	64	Web of Science, Scopus, ScienceDirect	2010–2020	Bibliometric	Systematic Review, Descriptive Analysis, Content Analysis, Bibliometric Analysis	VOSviewer	Mix
[74]	Status quo of the global research on CE implementation in the building industry	7000	Scopus, Web of Science	2005–2020	Bibliometric	Bibliometric Analysis (Co-Word, Co-Citation, And Co-Authorship Analyses)	Bibliometrix R-Package and VOSviewer	Quantitative
[128]	Dimensions of CE in the built environment	368	Scopus	All Years Till 2020	Bibliometric	Systematic Literature Review, Bibliometric Analysis, Content Analysis	R Software	Mix

As evidenced by the summary in Table 1, CC-related review studies have highlighted their contributions across various dimensions, primarily through qualitative analyses. These studies have systematically explored the barriers, challenges, and success factors influencing CE implementation in construction [113–116].

CE implementation has also been examined in specialized areas like CDWM [118,119], life cycle assessment [71,120], and value chain optimization [14]. Given the nascent nature of this field, researchers have focused on identifying potential threats and opportunities, leading to a deeper understanding of CC implementation challenges.

Mixed-method and quantitative reviews in this context provide a broad spectrum of perspectives on the CE domain within the construction industry. Systematic literature reviews and bibliometric analysis have been the key methods employed within this scope. These studies have effectively mapped the existing literature and connections, offering valuable insights into the current state of research. This analysis has revealed current research trends and gaps [60,122,123], defined circularity indicators in the construction sector [57,124], documented advancements in CC [127], and investigated barriers to adopting digital technology-enabled CE in the construction sector [109].

Most studies have overlooked Bibliometrix R for data analysis, with only two studies utilizing it [74,128]. Norouzi et al. [74] reviewed the CE in the building and construction sector-related studies with the R package and VOSViewer. Similarly, Mhatre et al. [128] presented a review of the evolution of literature and the development of theory in the CE in the built environment field. However, none of these studies investigate B2CC holistically.

This study's comprehensive methodology offers a multi-dimensional understanding of the B2CC research landscape. Synthesizing diverse viewpoints and identifying interconnected trends provides a broader, more cohesive perspective, setting it apart from prior research. This approach deepens our current understanding and uncovers new pathways for future investigations, making it a significant contribution to the B2CC domain.

Despite extensive research on various aspects of CC, there is a noticeable gap in terms of integrative studies that unify these fragmented insights into a cohesive framework. This study addresses that gap by employing a comprehensive methodology and utilizing sophisticated analysis tools to synthesize diverse perspectives and highlight emerging trends. This approach not only bridges the divide between isolated findings but also provides a more nuanced understanding of B2CC, laying the groundwork for future research to build on a unified and innovative foundation.

3. Materials and Methods

To achieve the current study's objectives and address the research questions, the authors utilized the science mapping method to analyze the literature on B2CC. The methodology employed in this study is similar to that used by Wang et al. [129] and Ye et al. [130], who also applied science mapping. Science mapping is a comprehensive approach to analyzing and visualizing a specific domain [131,132], focusing on the spatial representation of relationships between the disciplines, fields, and authors within a given body of literature [133]. This method is particularly effective for identifying key patterns and trends in large literature and bibliographic information datasets, offering insights that other methods may overlook [134].

Beyond assessing the impact of research, the science mapping approach also evaluates peer-reviewed journals, providing researchers with a deeper understanding of scientific knowledge and citation patterns [135,136]. The methodology consists of four main steps: bibliometric search, scientometric analysis, content analysis, and qualitative discussion [137]. A detailed overview of the research methodology is illustrated in Figure 1.

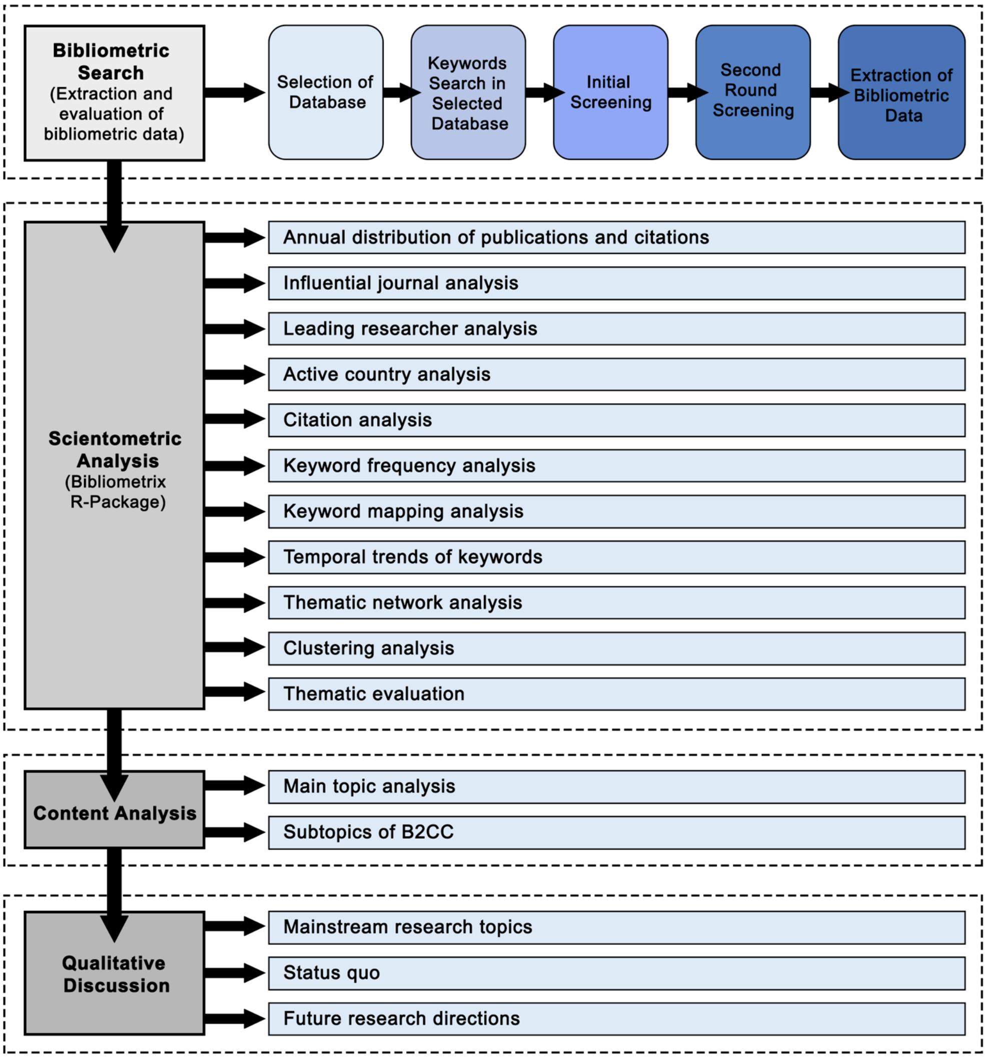


Figure 1. Framework of the methodology.

3.1. Bibliometric Search

The initial phase of this bibliometric search involves selecting a database to ensure the collection of high-quality data for analysis. Consistent with numerous previous bibliometric studies [65,138,139], this research employed the Web of Science (WoS) core collection database. WoS is widely regarded as the gold standard for bibliometric analysis, due to its rigorous global indexing of key literature [140]. Additionally, WoS utilizes advanced citation-matching algorithms that surpass those of Scopus [141], further validating its selection as the primary data source for this study [142].

In alignment with the study's objectives, appropriate keywords were selected to focus on research addressing the barriers to circular construction and the advantages of implementing a CE within the construction sector. The literature search was conducted using the WoS database, which is widely acknowledged as a high-quality source of bibliometric data for academic research [143]. Before the launch of Scopus in 2004, WoS was the primary systematic source for evidence-based decision-making support for funders and governmental bodies [144]. Additionally, WoS continues to be a robust academic resource that indexes studies and journals relevant to the circular economy in the construction industry. In this context, the search was performed using the following search string in the "ALL FIELDS" category: ("circular economy" OR "circular econom *" OR "circularity") AND ("construction industry" OR "construction") AND ("barrier") NOT ("infrastructure" OR "road").

This search string, combined with specific filters (e.g., document type—articles, review articles, and early access only; publications year—papers that had been published in the previous 10 years; language—English only), yielded 47,613 records in WoS as of August 2024. Building on this filtering, conference papers, books, and book chapters were excluded from this study due to common criticisms regarding their lack of rigorous peer reviews [65]. Conference papers, books, and book chapters often undergo a less rigorous peer review process compared to journal articles, which may compromise the reliability and validity of their findings. As Shi et al. [65] highlighted, relying on peer-reviewed journal articles ensures a high standard of scholarly rigor, making the results more dependable for forming conclusions and recommendations. Including such sources could dilute the methodological integrity of the study by incorporating findings that might not meet the same quality benchmarks as journal articles.

The time of publications was used as a criterion for screening the studies included in this review. Papers published earlier than 10 years ago were included to ensure that the studies reviewed are up to date and reflect the latest advancements in the field.

The choice to include only English-language articles is primarily pragmatic, given that English is the predominant language of global academic publishing and is most widely indexed in databases like the WoS. Furthermore, in B2CC research, global academic discourse predominantly occurs in English, which functions as the lingua franca of the scholarly community [145]. This ensures accessibility and standardization in the data analysis process. While excluding non-English papers may limit the breadth of perspectives, it ensures consistency in the methodology and avoids potential issues with translation accuracy, which could inadvertently bias the results. Moreover, the exclusion of non-English articles is justified by the need for uniformity and comprehensibility in the review process. Language barriers can introduce significant challenges in accurately interpreting and synthesizing research findings, which can compromise the integrity of the search [146]. The bibliometric search emphasizes the importance of a comprehensive search for relevant literature, but it also necessitates that the included studies are accessible and understandable to the reviewers [146]. This is particularly crucial when synthesizing findings in order to draw broad theoretical conclusions, as highlighted by Siddaway et al. [146].

In summary, expanding the scope to include non-English sources, conference proceedings, or book chapters risks diluting the study's focus and compromising its replicability and methodological rigor. By prioritizing systematic and credible bibliometric analysis, this study strikes a balance between inclusivity and analytical precision. This approach ensured the development of a robust dataset for the subsequent screening process, identifying documents relevant to B2CC research.

Subsequent screening was conducted on these 47,613 documents to further narrow the selection to those relevant to the construction industry and the circular economy, as scoped for this study. This process involved examining the titles, abstracts, and keywords of the records using specific queries such as "construction", "build", "building", "architecture", "AEC", "project", or "engineering". A total of 5968 articles passed this screening process and moved to the next stage. To ensure that only relevant and high-quality research publications were included, well-defined inclusion and exclusion criteria were established. The inclusion criteria were as follows: (1) studies explicitly focused on B2CC, (2) research published in peer-reviewed journals, and (3) studies indexed in SCI-E, SSCI, and AHCI. This selective approach toward academic journals was intentional, as these publications are generally held to higher standards of quality [65]. The exclusion criterion was: (1) studies published in languages other than English. After applying these criteria, 199 articles that fully complied with the determined filters from the entire screened pool were included in this study. The final phase involved evaluating the collected data. The obtained articles totaled 199 and were exported as BibTex files for scientometric analysis. The phases and details of the bibliometric search and the extraction of bibliometric data are presented in Figure 2.

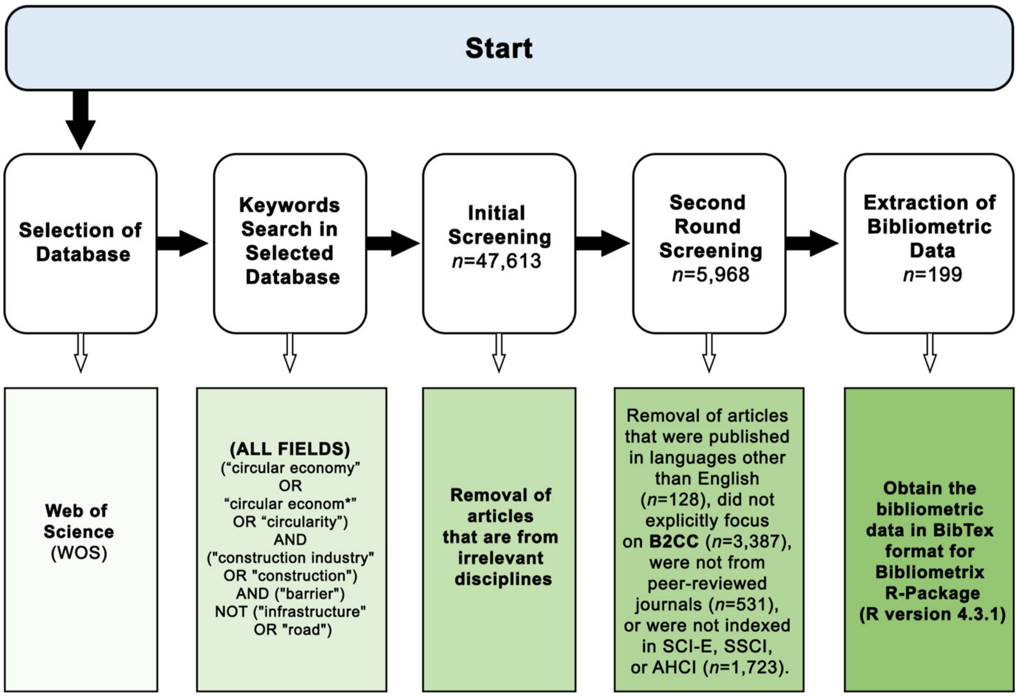


Figure 2. Extraction of bibliometric data phases.

3.2. Scientometric Search

In this study, the second step was scientometric analysis, an analytical method commonly employed to assess the development of scientific disciplines, authorship trends, and the generation of scientific knowledge [147]. We utilized the R programming's scientific mapping system to perform a quantitative scientometric analysis of the literature from the WoS database [147]. Scientometric analysis charts the prevalence of interconnected themes within search engines and identifies those areas that need more substantial academic exploration [148,149]. We employed the R package's Bibliometrix tool, as Aria and Cuccurullo [150] outlined, to conduct the scientometric analysis of the chosen relevant articles. Various software platforms, such as VOSViewer, CiteSpace, SciMAT, CoPalRed, and Bibexcel, can be used for bibliometric analysis [151]. However, many of these tools involve complex processes that can be challenging for researchers to navigate [150]. In contrast, Bibliometrix, a recently developed software package within the R environment, distinguishes itself by offering greater adaptability and integrated graphical functionalities than other bibliometric tools. This study utilized the flexibility and advanced features of Bibliometrix in RStudio to perform a comprehensive scientometric analysis of the B2CC research area.

To examine B2CC, we employed the R package Bibliometrix tool to analyze the scientometric connections derived from specific findings. Scientometric analysis based on 10 criteria was performed on the downloaded dataset: (1) changes in publications quantity, (2) journals' production over time and influential journals, (3) leading researchers, (4) publications per country, (5) the most frequently cited publications, (6) Keywords Plus frequency, (7) co-occurrence keyword mapping, (8) thematic mapping, (9) keyword cluster mapping, and (10) thematic evaluation.

The articles obtained from the bibliometric search were rigorously analyzed using R programming. Various attributes of the articles, including "author", "document type", "journal", "language", and "number of cited documents", were assessed, with complete data records obtained for most attributes. Minor discrepancies were observed in the "affiliation", "cited references", "corresponding author", and "DOI" (less than 1%), and in "keywords" (less than 5%). However, there was an acceptable data gap of 10.05% in Keywords Plus, primarily due to author omissions (Table 2). Articles lacking keywords were excluded from keyword-based analyses but were included in all other study aspects.

Table 2. The integrity of the bibliographic metadata imported into RStudio.

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0.00	Excellent
AU	Author	0	0.00	Excellent
DT	Document Type	0	0.00	Excellent
SO	Journal	0	0.00	Excellent
LA	Language	0	0.00	Excellent
NR	Number of Cited References	0	0.00	Excellent
PY	Publications Year	0	0.00	Excellent
TI	Title	0	0.00	Excellent
TC	Total Citation	0	0.00	Excellent
C1	Affiliation	1	0.50	Good
CR	Cited References	1	0.50	Good
RP	Corresponding Author	1	0.50	Good
DI	DOI	1	0.50	Good
DE	Keywords	3	1.51	Good
ID	Keywords Plus	20	10.05	Acceptable

3.3. Content Analysis

While bibliometric searches and scientometric analysis serve as valuable tools for assessing academic contributions, they lack the ability to provide detailed insights into specific topics of interest [152]. To address this limitation, content analysis was utilized to explore the themes present in the dataset more thoroughly. This qualitative research method is designed to interpret meanings derived from textual data.

4. Results

4.1. Overview of B2CC Research

4.1.1. General Overview of the Obtained Data and Distribution of Annual Publications and Citations

Table 3 offers an overview of the key data characteristics, covering the period from 2017 to 2024, and includes 61 distinct sources and a total of 199 documents—the average time since publications is 1.86 years, with an average of 34.63 citations per document. There are 9541 references, reflecting the emergence of a relatively new research domain with a limited number of publications. Many of these papers have been published in recent years and have accumulated many citations, indicating a growing interest in the field. The annual growth rate is 44.78%.

Using RStudio's Bibliometrix, insights into the annual distribution of document volumes and their associated citations were extracted. This analysis included metrics such as average yearly citations, publications counts, and cumulative citation counts, as visually represented in Figure 3.

Table 3. The overview of the data characteristics.

Description	Value
Timespan	2017–2024
Sources	61
Documents	199
Documents' average age	1.86
Annual percentage growth rate	44.78%
Average citations per document	34.63
Authors	584
Authors of single-authored articles	9
Authors of multi-authored articles	575
References	9541

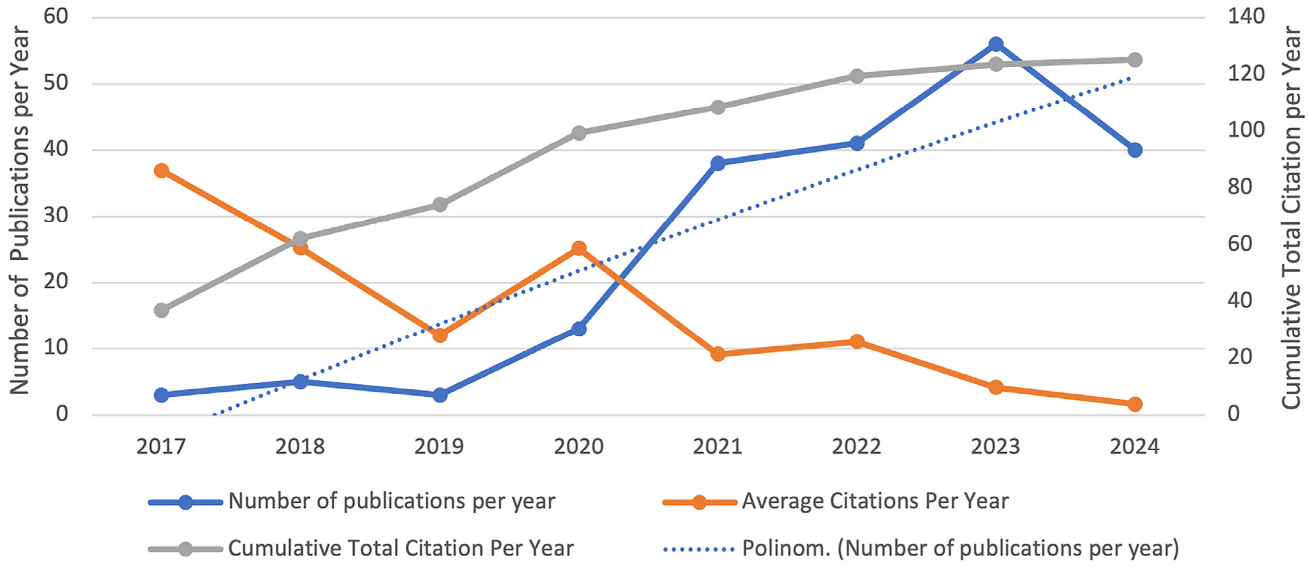


Figure 3. Distribution of B2CC publications and their citations per year.

Figure 3 illustrates a consistent upward trend in publications addressing B2CC from 2017 to 2024, marked by an annual growth rate of 44.78% despite minor fluctuations, and reached the peak of publications in 2023. This indicates that the B2CC topic is increasing in popularity. The increase in publications addressing the barriers to circular economy construction in 2022 can be attributed to various factors identified in the literature. The construction industry is acknowledged as a resource-intensive sector where adopting circular economy principles is crucial, to minimize its global impacts and conserve natural resources [153]. Furthermore, the EU's development of standardized methods focusing on the circular economy in the construction sector has emphasized considering operational and embodied carbon emissions in new building designs [76]. This regulatory drive toward sustainability and circularity probably contributed to this field's heightened interest and research output. Furthermore, considering the data collected up to August 2024, the number of publications within this domain is expected to surpass that in 2023 by the end of 2024.

An analysis of the cumulative total citation trend over the years showed a consistent and steady rise, reflecting the increasing interest in B2CC. In contrast, the average number of citations per year exhibited fluctuations, with noticeable variations from one year to the next.

4.1.2. Influential Journals

The importance of sources is highly relevant. They provide valuable insights into the journal landscape, their influence and impact, and the shifting publications trends. Within this study, 61 journals are distributed among the 199 articles analyzed. Figure 4 represents the 11 most significant sources, each containing more than four articles. The top five journals alone account for one-third of the total publications. In particular, the ranking is headed by *Sustainability*, with 34 articles (17.0%), indicating a clear commitment to dissemination in B2CC research. It is followed by the *Journal of Cleaner Production* (14.5%), *Buildings* (7.5%), the *Journal of Building Engineering* (4.5%), and farther away, *Sustainable Production and Consumption* (4.0%). In contrast, from a chronological point of view, from 2017, the *Journal of Cleaner Production* was always at the forefront regarding B2CC until the second half of 2022. It slightly exceeded the number of articles published after the second half of 2022 by *Sustainability*, which has continued its exponential growth up to the present.

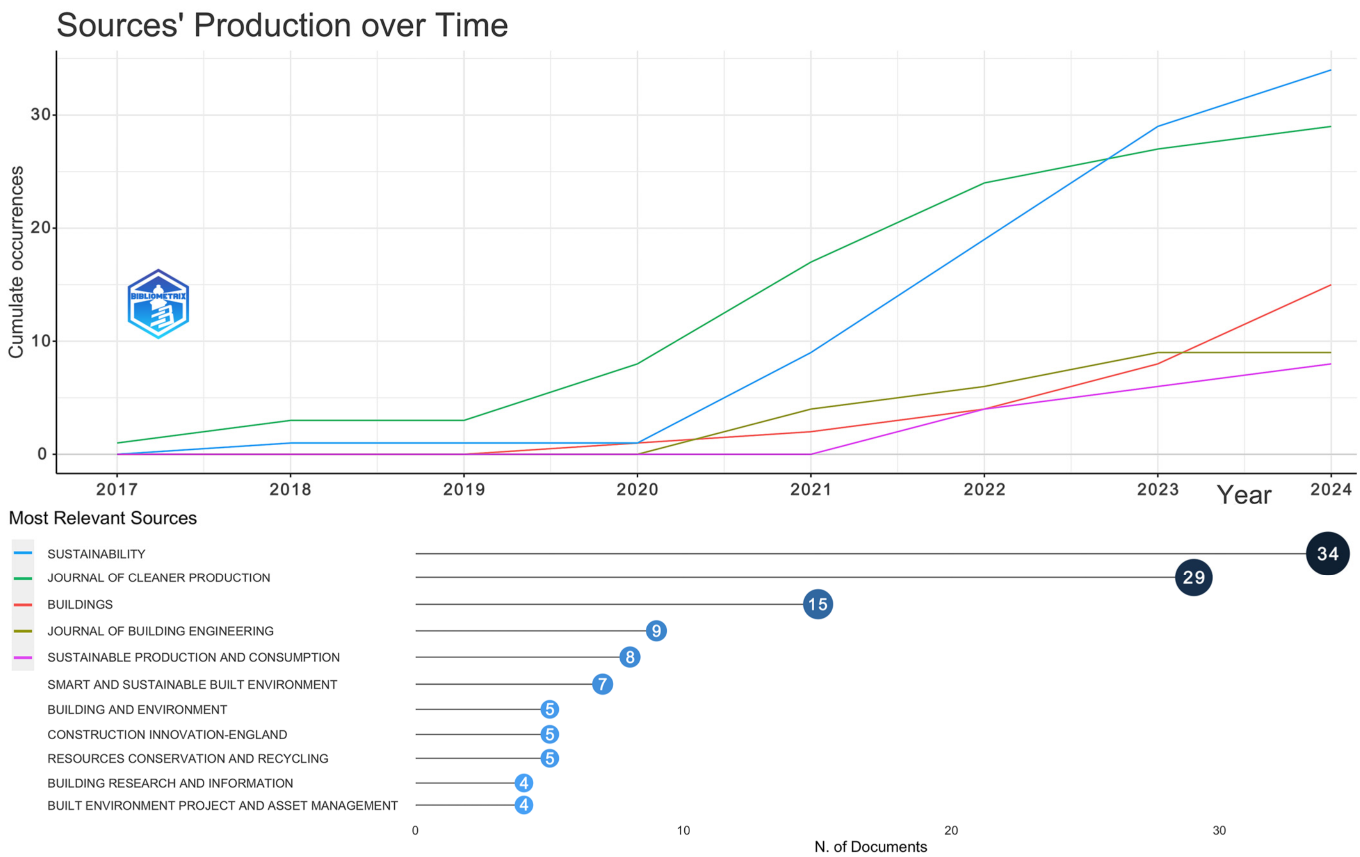


Figure 4. Journals' production over time.

Besides the number of publications, the *h*-index of each journal is a significant measure by which to identify the most relevant and influential journals in the B2CC domain. Table 4 represents the *h*-index of the journals in Figure 4.

As seen from Table 4, the most influential sources are the *Journal of Cleaner Production*, *Sustainability*, and the *Journal of Building Engineering*, in descending order. Although *Sustainability* is in first place based on the number of publications in the B2CC domain (Figure 4), the *Journal of Cleaner Production* is in first place based on the *h*-index, which confirms it as the most influential journal.

Table 4. The *h*-index of influential journals in the B2CC domain.

Description	Value
Journal of Cleaner Production	22
Sustainability	10
Journal of Building Engineering	7
Buildings	5
Resources Conservation and Recycling	5
Sustainable Production and Consumption	5
Smart and Sustainable Built Environment	4
Building and Environment	3
Building Research and Information	3
Built Environment Project and Asset Management	3
Construction Innovation-England	3

4.1.3. Leading Researchers

Key researchers in the field were identified by an in-depth analysis of author information within the compiled dataset. Table 5 presents the top 10 leading scholars who have contributed significantly to B2CC articles. This ranking is based on critical indicators, including the *h*-index, total citations (TC), the number of publications (NPs), and the year in which they first contributed to the field of B2CC (PY-start).

Table 5. The top 10 leading researchers in the field of B2CC.

No	Author	*h*-Index	TC	NP	PY-Start
1	LU W	5	389	6	2019
2	ANTWI-AFARI P	4	327	4	2020
3	CHAREF R	4	197	5	2021
4	NG ST	4	310	4	2020
5	WUNI IY	4	122	6	2022
6	AGYEKUM K	3	23	4	2023
7	AMUDJIE J	3	23	3	2023
8	BAO Z	3	321	3	2019
9	BRAGANCA L	3	228	4	2020
10	CHAN DWM	3	121	3	2022

As shown in Table 5, Lu W. is the most prominent academic in the domain of B2CC, as evidenced by his greatest *h*-index value and TC. In terms of the *h*-index, he is succeeded by Antwi-Afari P., Charef R., Ng ST., and Wuni IY.

Given a sample of 199 papers, a wide range of scholars from various countries was anticipated. A threshold of at least three papers was established to identify the most relevant researchers, resulting in 25 co-authors meeting this criterion. Figure 5 presents a diagram organized by each author's chronological output from 2019 (when B2CC began to gain prominence) to 2024.

The beige line represents each author's timeline, with Lu's timeline spanning from 2019 to 2023. The size of the bubbles corresponds to the number of articles published; Charef and Wuni co-authored a maximum of three articles in 2021 and 2022, accumulating 197 and 122 citations, respectively.

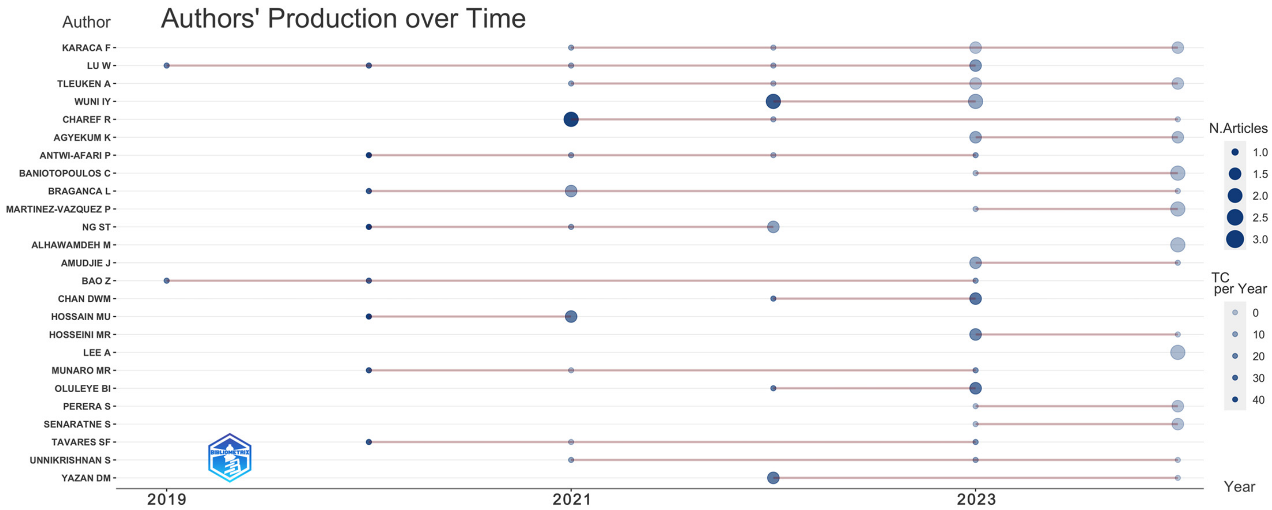


Figure 5. Top authors' production rates over time.

Finally, the intensity of the blue shading correlates with the number of citations per year, with Hossain et al. [28] and Munaro et al. [14] receiving 45.0 and 35.4 citations per year, respectively, in 2020. At the other end of the spectrum are emerging authors like Amudjie, Alhawamdeh, and Lee, who, despite having a shorter track record, have demonstrated high productivity, publishing three articles in just the first half of 2024. As highlighted in Figure 5, the peak level of contributions was observed in 2023 (with 2024 still ongoing). The insights from this analysis will be valuable for future research, aiding in identifying the leading authors in B2CC based on their experience and productivity over time, whether they are established authorities or emerging scholars. This approach will help researchers stay current with developments in the field and facilitate the planning of future collaborations across institutions.

4.1.4. Active Country Analysis

In-depth data analysis revealed active participation in B2CC research across 46 countries. Figure 6 provides a detailed overview of the 20 leading countries of the corresponding authors in B2CC articles.

The leading countries in terms of the number of published articles in the B2CC field are Australia and China, each contributing 24 articles. Of these, Australia has 15 single-country publications (SCPs), where all authors are based in Australia, and 9 multiple-country publications (MCPs) that involve international collaboration. Similarly, China has 17 SCPs authored exclusively by Chinese researchers and 7 MCPs involving authors from different countries. Australia and China each account for 12% of the total publications, reflecting a significant level of engagement from authors in these countries. The United Kingdom (UK) ranks second, with 21 articles, comprising 12 SCPs and 9 MCPs, representing 10.5% of the total. The Netherlands is the third most prolific country, contributing 10 articles, including 6 SCPs and 4 MCPs, making up 5.0% of the total. It is significant that India, Denmark, and Slovakia, notably, have no collaborative efforts. Figure 6 provides a visual summary of this information.

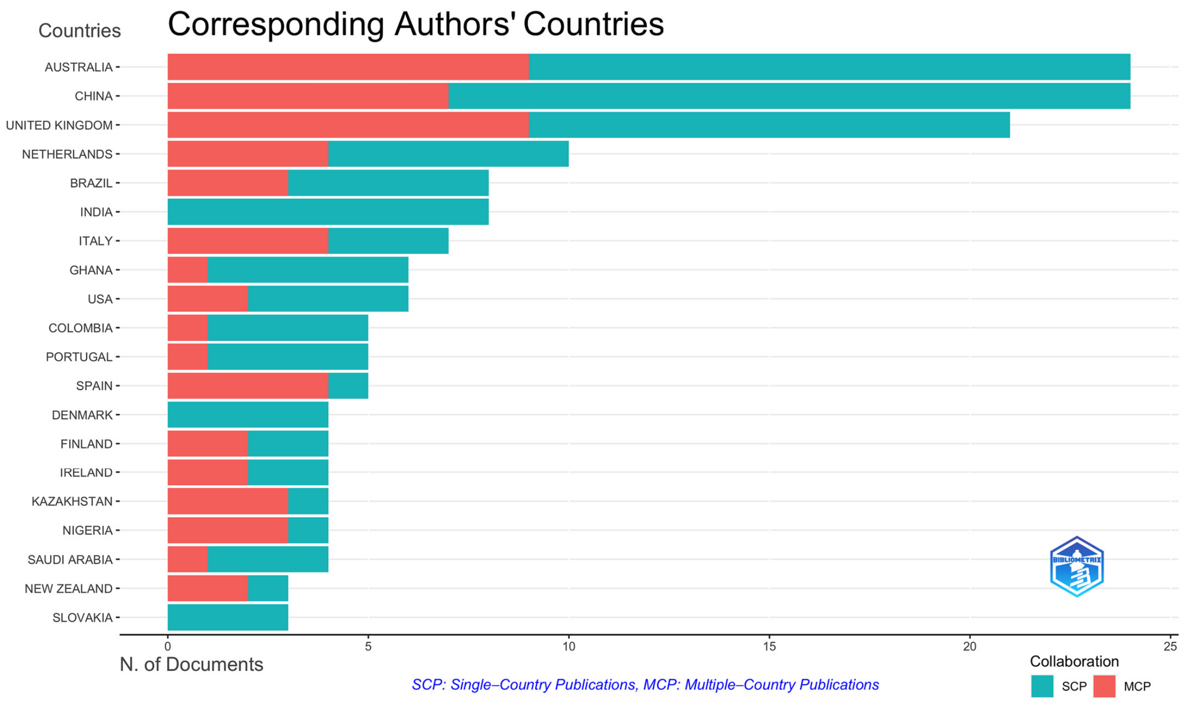


Figure 6. The top 20 most relevant corresponding authors' countries.

4.1.5. Citation Analysis

Citation analysis, a widely used method for exploring a research domain's underlying intellectual structure and evolutionary dynamics in several research domains, is employed herein to identify and examine the most frequently cited papers in the B2CC domain, along with their interrelationships. Table 6 highlights the top 20 papers that have garnered more than 100 total citations (TC) in descending order, selected from a pool of 174 articles with at least 1 citation. TC refers to the number of times a paper has been cited within the WoS core collection database, indicating its influence within that academic circle. In contrast, local citations (LC) represent the number of times that a document has been cited by papers within the collected dataset (comprising 199 articles), serving as an indicator of the paper's impact within the B2CC domain. Pomponi and Moncaster [17] achieved the highest LC with 66 and the highest total TC with 452, surpassing other documents in both categories. However, their paper's normalized total citations (NTC) are relatively low, at 1.53, which is lower than the NTCs of other papers listed in Table 6. The NTC metric adjusts for variations in citation practices across different disciplines, offering a more meaningful comparison of citation impact [154]. This metric ensures equal credit for citations to all authors of a paper while accounting for the average citations per document, as recorded in the database for the year of publications [155]. For instance, in our dataset, the average number of citations per year for the three papers published in 2017 is 295.3. For Pomponi and Moncaster [17], with a TC of 452, the NTC is calculated by dividing the TC by this average, resulting in an NTC of 1.53.

In contrast, Zhang et al. [87], who ranked eleventh in terms of TC but first in terms of NTC with a value of 5.20, were awarded this rank by dividing their TC of 172 by the average citations per year for the 40 papers published in 2022, which is 32.6. Recognizing that earlier articles typically have more time to accumulate citations is essential. Therefore, when comparing citations across different periods, a higher or lower TC does not necessarily reflect a greater or lesser impact [156].

Table 6. Top global and local cited articles in B2CC.

Main Author	Year	Title	Source	LC	TC	TCpY	NTC	Ref.
Pomponi, F.	2017	Circular economy for the built environment: A research framework	Journal of Cleaner Production	66	452	56.50	1.53	[17]
Ghisellini, P.	2018	Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector: A literature review	Journal of Cleaner Production	56	307	43.86	1.74	[24]
Benachio, GLF.	2020	Circular economy in the construction industry: A systematic literature review	Journal of Cleaner Production	0	288	57.60	2.29	[157]
Adams, KT.	2017	Circular economy in construction: current awareness, challenges and enablers	Waste and Resource Management	0	286	35.75	0.97	[88]
Mahpour, A.	2018	Prioritizing barriers to adopt circular economy in construction and demolition waste management	Resources, Conservation and Recycling	0	252	36.00	1.43	[158]
Leising, E.	2018	Circular Economy in the building sector: Three cases and a collaboration tool	Journal of Cleaner Production	49	247	35.29	1.40	[106]
Lopez Ruiz, LA.	2018	The circular economy in the construction and demolition waste sector—A review and an integrative model approach	Journal of Cleaner Production	0	242	48.40	1.93	[114]
Hossain, MU.	2020	Circular economy and the construction industry: existing trends, challenges and prospective framework for sustainable construction	Renewable & Sustainable Energy Reviews	54	225	45.0	1.79	[28]
Munaro, MR.	2020	Towards circular and more sustainable buildings: A systematic literature review on the circular economy in the built environment	Journal of Cleaner Production	38	177	35.4	1.41	[14]
Norouzi, M.	2021	Circular economy in the building and construction sector: A scientific evolution analysis	Journal of Building Engineering	31	175	43.75	4.79	[74]
Zhang, C.	2022	An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe	Science of the Total Environment	0	172	57.33	5.20	[87]

Table 6. *Cont.*

Main Author	Year	Title	Source	LC	TC	TCpY	NTC	Ref.
Bao, Z.	2020	Developing efficient circularity for construction and demolition waste management in fast emerging economies: Lessons learned from Shenzhen, China	Science of the Total Environment	0	157	31.4	1.25	[159]
Esa, MR.	2017	Developing strategies for managing construction and demolition wastes in Malaysia based on the concept of circular economy	Journal Material Cycles and Waste Management	0	148	18.50	0.50	[160]
Bao, Z.	2019	Procurement innovation for a circular economy of construction and demolition waste: Lessons learnt from Suzhou, China	Waste Management	0	135	22.5	1.88	[161]
Ginga, CP.	2020	Circular Economy on Construction and Demolition Waste: A Literature Review on Material Recovery and Production	Materials	13	132	26.40	1.05	[162]
Joensuu, T.	2020	Circular economy practices in the built environment	Journal of Cleaner Production	18	125	25.00	0.99	[163]
Guerra, BC.	2021	Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers	Resources, Conservation and Recycling	0	114	28.50	3.21	[75]
Bilal, M.	2020	Current state and barriers to the circular economy in the building sector: Towards a mitigation framework	Journal of Cleaner Production	35	113	22.60	0.90	[91]
Ogunmakinde, OE.	2022	Contributions of the circular economy to the UN sustainable development goals through sustainable construction	Resources, Conservation and Recycling	0	109	26.33	3.29	[164]
Sholaei, A.	2021	Enabling a circular economy in the built environment sector through blockchain technology	Journal of Cleaner Production	8	105	26.25	2.87	[165]

LC: Local citations. TC: Total (global) citations. TCpY: Total citations per year. NTC: Normalized total citations. Normalized local citations.

4.2. Keyword Analysis

Keyword frequency analysis, keyword mapping, and temporal trends analysis have been conducted as part of keyword analysis.

4.2.1. Keyword Frequency Analysis

This study carried out an extensive scientometric analysis using a set of 349 keywords extracted from 199 articles. Some keywords had synonymous or similar meanings, which could lead to inaccuracies. Unlike other scientometric software, the R-tool can consolidate these terms by grouping similar words under primary representatives, as shown in Table 7. This approach enhances the accuracy of the keyword analysis by addressing any potential challenges related to synonymy.

Table 7. Synonymous words.

Word	Consignification
barriers	challenges; prioritizing barriers
material flows	material flow-analysis; material flow
material stocks	material stock
benefits	benefit
big data	big-data
built environment	built-environment
business models	business model
carbon	carbon footprint; carbon sequestration
city	cities; city level
collaboration	collaborations
cost	costs
eco-industrial	eco-industrial parks
emissions	emission
impact	impacts
organization	organizations
policy	policies
prefabrication	off-site construction
product	products
waste management	waste-management; waste minimization; demolition waste management; solid-waste management
demolition waste	waste; municipal solid-waste
transition	transitions
technologies	technology
system	systems
supply chain	supply chains; supply-chain
bibliometric analysis	scientometric analysis
recycled aggregate	recycled aggregate concrete; recycled concrete aggregate

Table 7. *Cont.*

Word	Consignification
life-cycle assessment	lca; assessment lca; life-cycle
sector	industry; construction-industry
deconstruction	building deconstruction
strategy	strategies

Figure 7 presents the most frequently used keywords and their corresponding frequencies in the B2CC domain. Each keyword is linked to data points represented by blue circles, with numerical values indicating the frequency of occurrence. The most common keywords in the dataset are “barriers”, “management”, “demolition waste”, “construction”, and “design”. This dataset highlights the challenges and management strategies when integrating circular economy principles into construction, focusing on overcoming the barriers related to demolition waste and sustainable design practices.

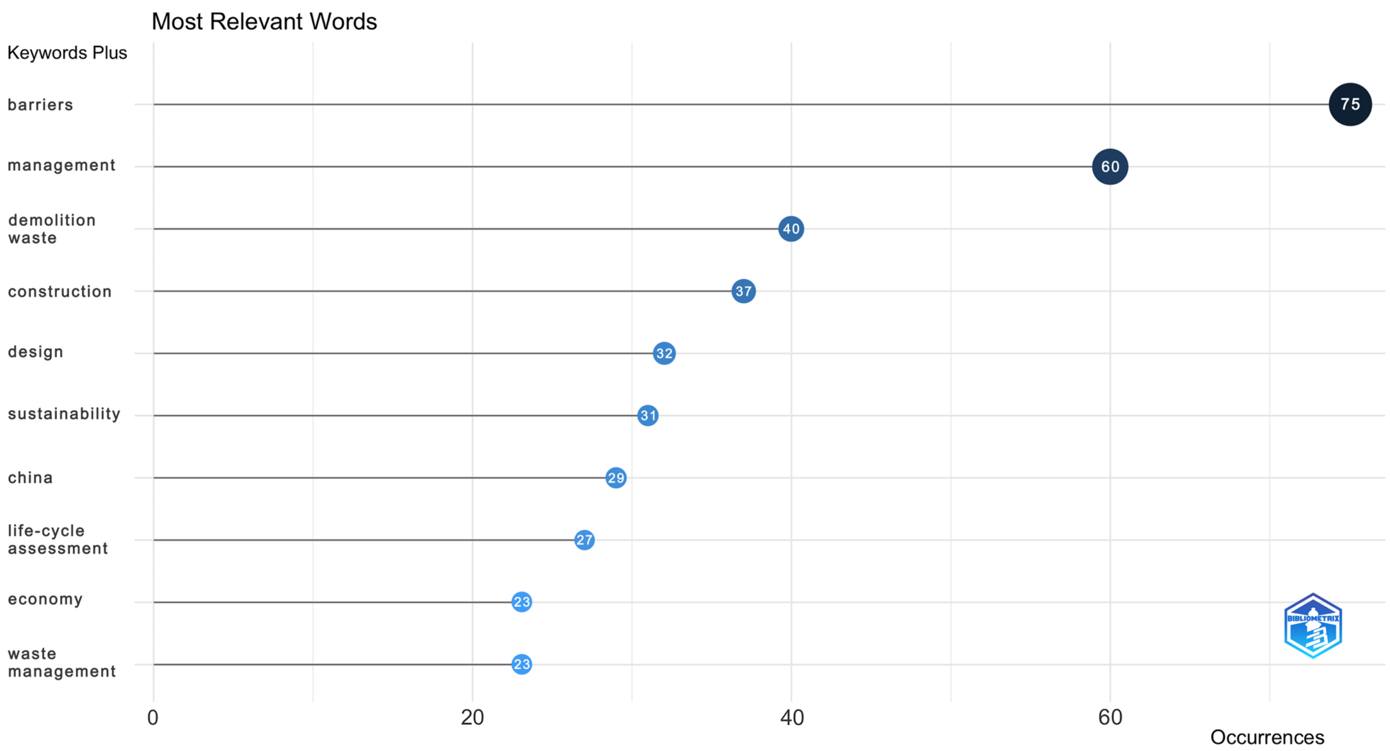


Figure 7. Frequently used Keywords Plus instances in the B2CC domain.

4.2.2. Keyword-Mapping Analysis

Typically, authors choose keywords for their articles, while indexers assign Keywords Plus terms to accurately reflect the article’s content. Unlike previous review studies, this study used data derived from Keywords Plus terms for the keyword-mapping analysis. The Walktrap algorithm [166], known for its effectiveness in detecting term communities, was employed to build a co-occurrence network that visualizes keyword mapping. This algorithm analyzes the structure of a word, generates nodes, groups them, and clusters similar nodes within the same community [166]. Figure 8 illustrates a network of keywords, where links represent their interactions. The size of the nodes and the thickness of the lines reflect the significance and frequency of these connections, respectively.

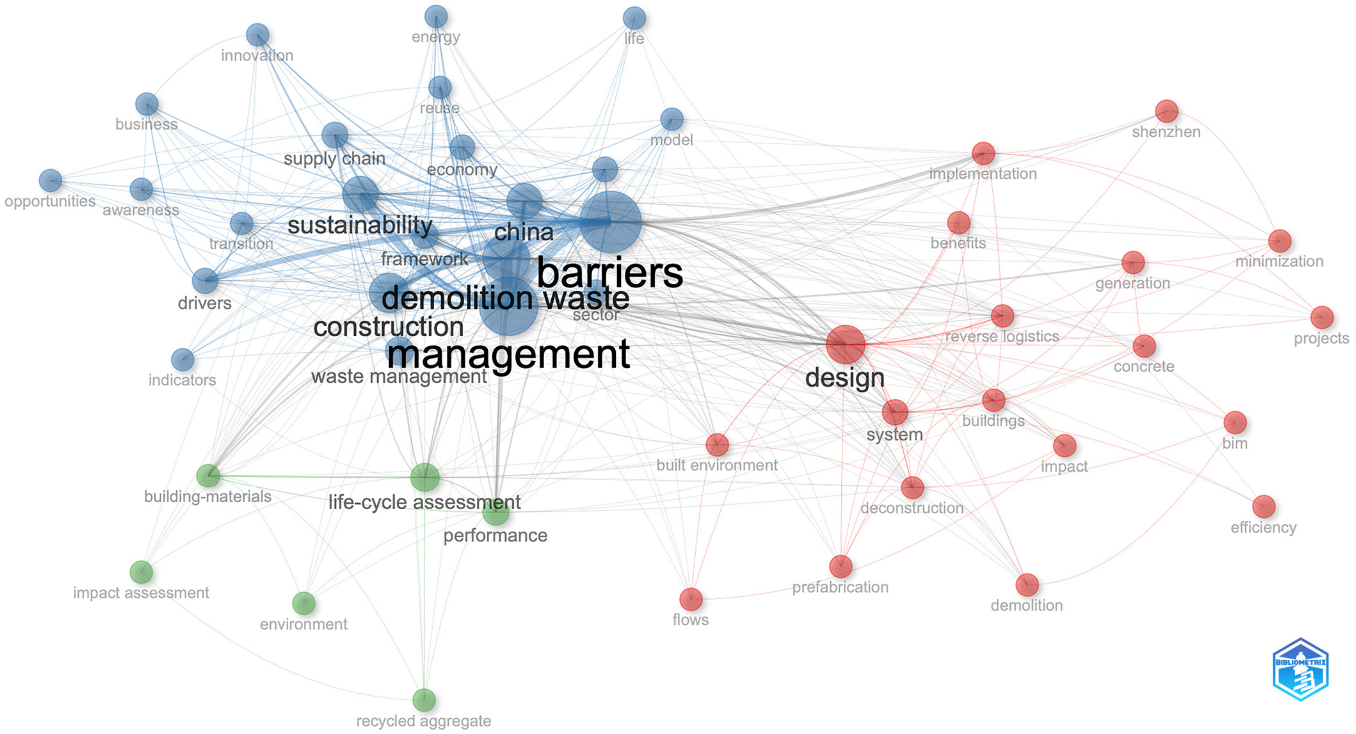


Figure 8. Scientific analysis map with the co-occurrence clusters of keywords based on B2CC.

Figure 8 shows the most prominent words to be "management", "barriers", "demolition waste", and "sustainability".

4.2.3. Temporal Trends of Keywords

Keyword trends from the past decade were analyzed to better understand how topics have evolved over different periods. Figure 9 displays the total number of occurrences of various keywords from 2017 to 2024, highlighting the changing frequency of keyword usage over time. This analysis provides valuable insights into their shifting patterns. The most prevalent keywords in the dataset include "management", "barriers", "construction", "design", and "sustainability".

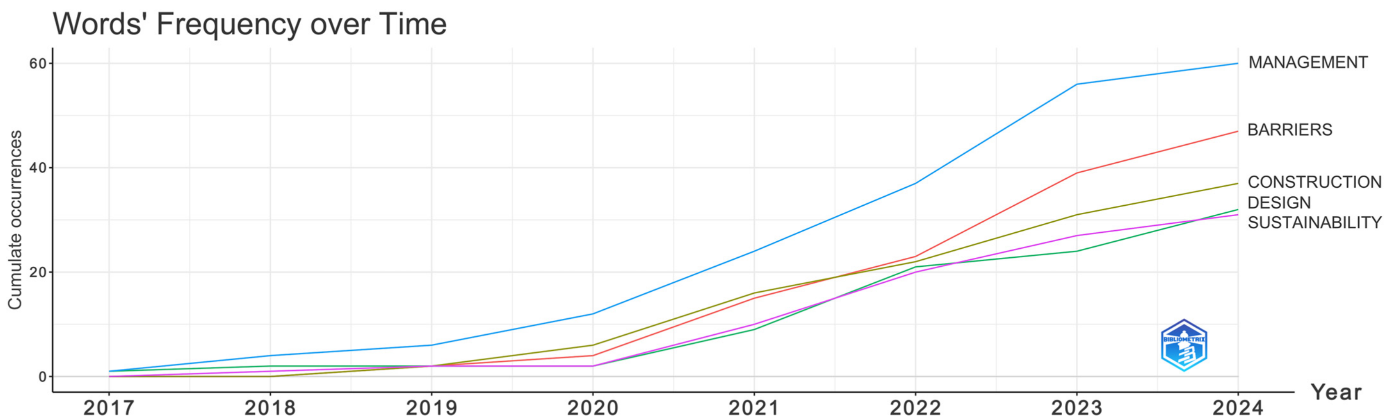


Figure 9. Total frequency, based on Keywords Plus.

Figure 9 reveals that early studies in this field initially focused on "management" in 2017. In the following years, particularly after 2019, researchers began to address issues related to "barriers", "construction", "design", and "sustainability". One significant reason for this shift could be attributed to several key factors. Early studies primarily concentrated on the management aspect of circular economy projects, probably to establish a foundational understanding of how circular practices could be integrated into construction processes [167]. As research progressed, the emphasis expanded to encompass a broader range of challenges and opportunities related to circular economy principles within the construction sector.

One significant reason for this evolution is the increasing recognition of barriers hindering the widespread adoption of circular economy practices in the construction industry. Studies have highlighted various obstacles, such as the need for more awareness and knowledge among professionals, limited understanding of circular economy principles, and the need for policy support to facilitate the transition toward circularity [168]. These barriers have prompted researchers to delve deeper into understanding and addressing these challenges to promote the effective implementation of circular economy concepts in construction projects.

Moreover, the growing emphasis on sustainability and environmental concerns globally has propelled the construction industry to explore innovative approaches like the circular economy to enhance resource efficiency and reduce environmental impact [169,170]. Integrating circular economy principles into construction processes is a strategic move toward achieving sustainability goals while promoting economic and social benefits [169,171].

Additionally, the emergence of research focusing on design and construction aspects within the circular economy framework reflects a shift toward proactive planning and implementation strategies that embed circularity from the early stages of project development [172]. By considering circular principles in the design and construction phases, stakeholders can optimize resource utilization, minimize waste generation, and enhance the overall sustainability performance of built environments.

4.2.4. Thematic Network Analysis

Thematic network analysis (TNA) was constructed using Bibliometrix through co-word analysis, utilizing Keywords Plus. This analysis included only those keywords with a minimum frequency of two occurrences to identify the most prominent and specific themes within this domain. Variations of keywords representing similar themes, as shown in Table 7, were merged, as before. Following this process, the most relevant keywords were organized into thematic clusters, named after the keywords with the highest occurrence. Based on the framework by Callon et al. [173], Figure 10 is divided into four quadrants, each representing different types of themes. Two metrics, centrality and density, describe each thematic cluster. Density reflects the level of interconnectedness among the themes within a cluster. A cluster is positioned higher on the diagram when the relationships among the words within it are strong, indicating the cluster's potential for growth. Centrality, conversely, represents the interactions between a particular cluster and other clusters. As a cluster's interactions with other clusters increase, it moves further to the right in the diagram [151,174].

TNA, as shown in Figure 10, demonstrated that "Motor" themes (Quadrant I) are characterized by high centrality and high density. This indicates their significance and well-developed nature in shaping the field of B2CC. "Niche" themes (Quadrant II) are specialized but may lack a broader context or significance. Although these themes exhibit solid internal connections, they are of limited importance within the B2CC domain. "Emerging/declining" themes (Quadrant III) are less frequently observed and might diminish, necessitating further qualitative analysis. These themes need to be more fully developed and have marginal relevance for the B2CC field. "Basic" themes (Quadrant IV), although significant due to their high centrality, remain underexplored. These themes are crucial for developing the B2CC field but must be sufficiently explored [151,174]. The cluster sizes suggest that most of the publications included terms from these clusters.

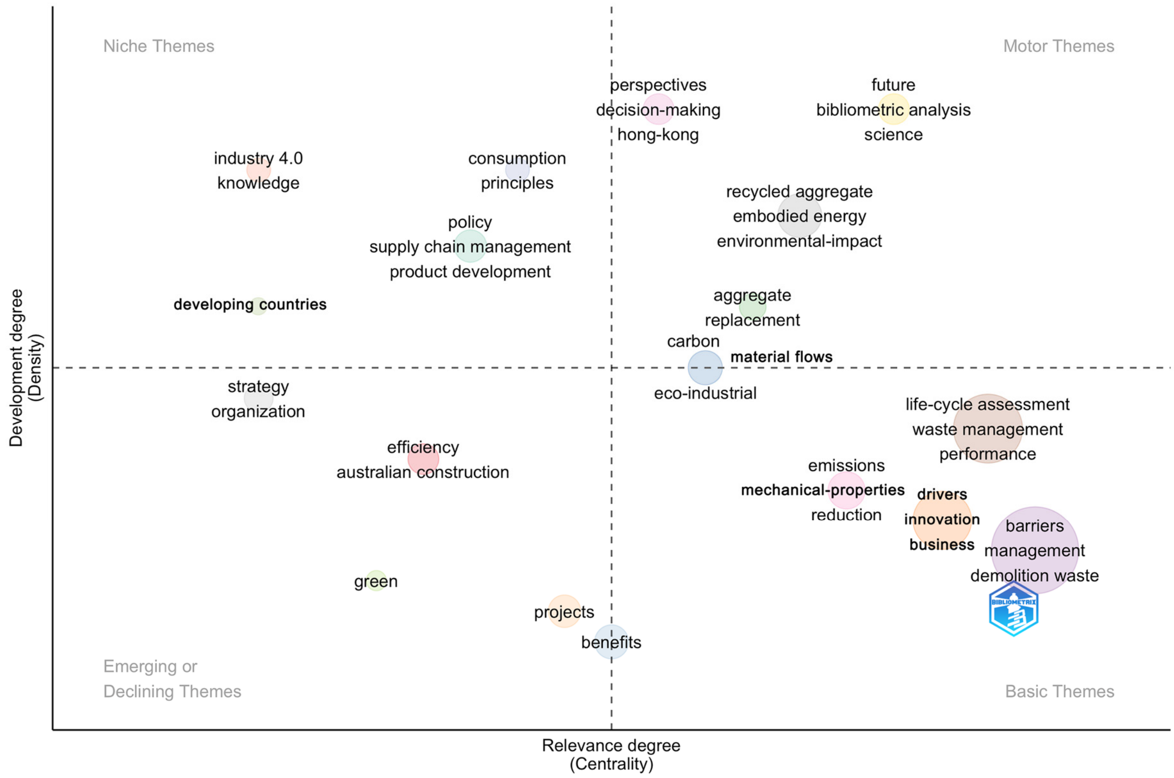


Figure 10. Thematic mapping.

A detailed analysis of the clusters within the "Motor" themes reveals that specific concepts, such as "bibliometric analysis", "future", and "science", are pivotal and hold substantial potential for further development in this domain, given their high density and centrality. Additionally, when examining the clusters within the "Motor" themes based on size, keywords like "recycled aggregate", "embodied energy", and "environmental impact" stand out, indicating that the majority of publications have incorporated terms from this cluster (Figure 10).

The cluster containing "carbon", "material flows", and "eco-industrial" is situated precisely along the density axis, reflecting its near-high centrality and moderate density within the clusters. This positioning underscores the importance of these concepts, although further research is needed to explore them comprehensively.

Themes such as "consumption", "principles", "policy", "supply chain management", "product development", and "industry 4.0" fall under the "Niche" themes in the second quadrant. This indicates that these themes are well-developed but are relatively isolated within the broader research context. Despite having solid internal relationships, they may be less influential in research related to B2CC. Furthermore, themes like "industry 4.0", "knowledge", and "developing countries" have contributed less to B2CC research, as reflected by their smaller cluster sizes.

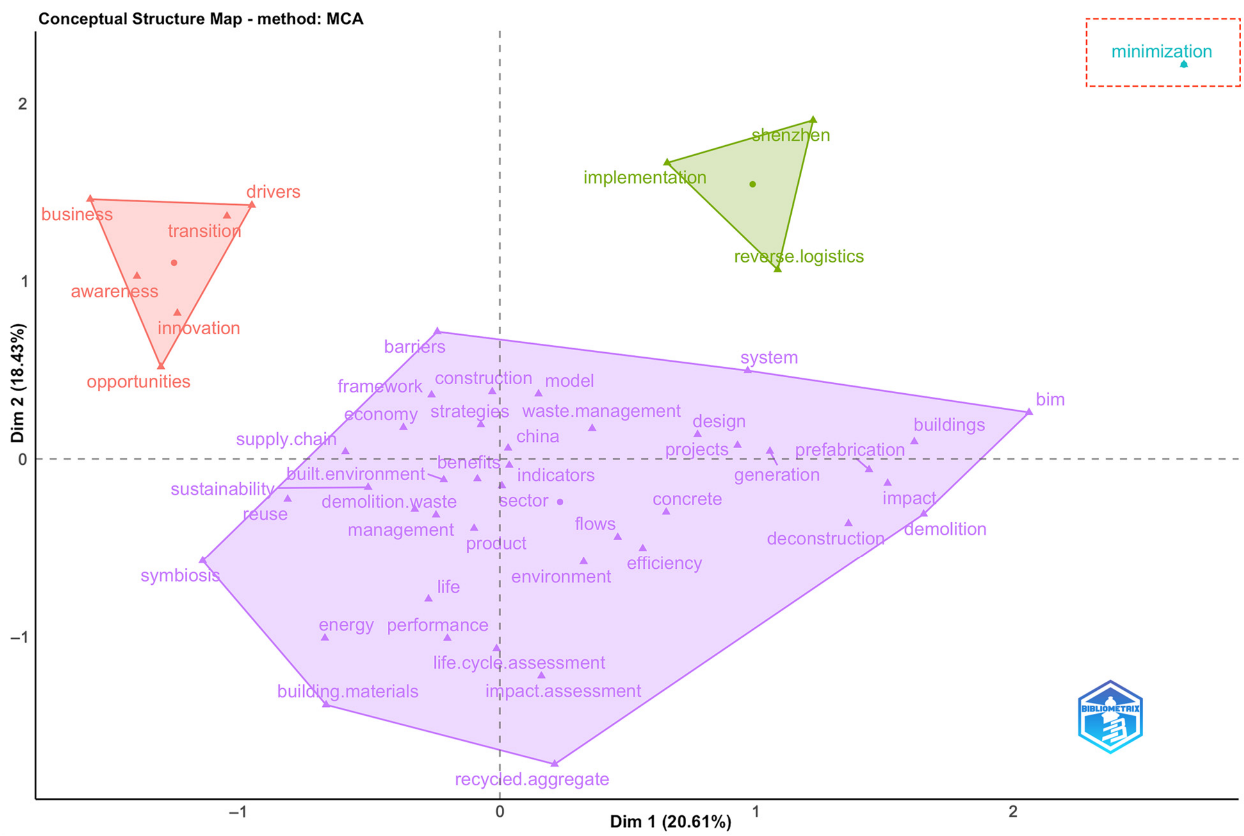
The terms "strategy", "organization", and "efficiency" are positioned in the third quadrant, categorized under "Emerging" or "Diminishing" themes. This suggests that these themes currently hold limited significance and require further qualitative analysis (Figure 10).

The fourth quadrant in Figure 10 represents the "Basic" themes, which are essential concepts in the field but have not been extensively explored. Key themes in this category include "life-cycle assessment", "waste management", "performance", "barriers", "management", and "demolition waste". Although the clusters in this quadrant exhibit weaker internal connections, they show strong associations with other clusters.

4.2.5. Multidimensional Scaling Analysis and K-Means Clustering Analysis

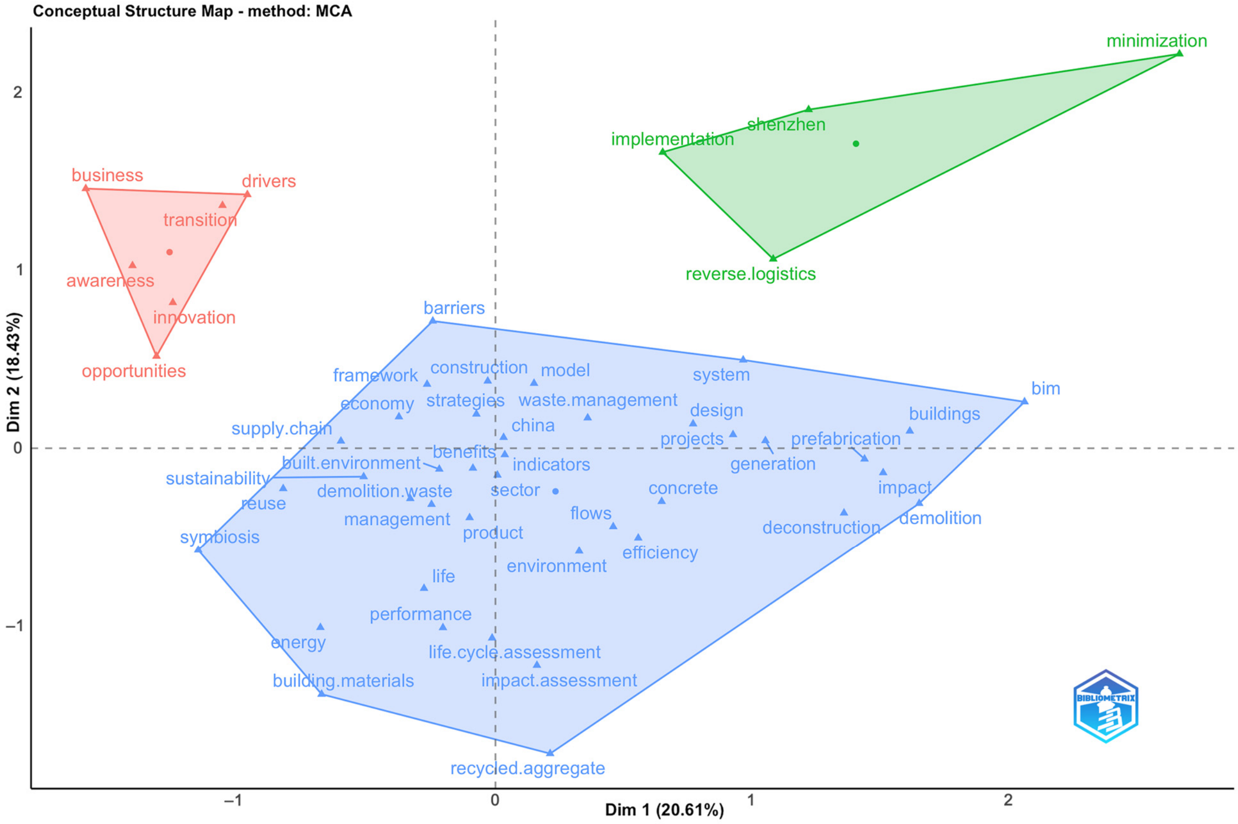
Subsequently, using the Conceptual Structure function of Bibliometrix, we generated a conceptual structure map of the B2CC research field, as shown in Figure 11. This function performs a multidimensional scaling analysis of keywords to draw the conceptual structure of a research domain and uses K-means clustering analysis to detect clusters of keywords that express common concepts [150]. Multidimensional scaling analysis is an exploratory analysis method that can show the relationship between multi-variables in two-dimensional space and helps detect the spatial distribution of topics. K-means clustering analysis is one of the most widely applied approaches in cluster analysis. It can cluster issues based on the distribution of the keywords along the dimensions and their relative positions. The top 50 high-frequency keywords in the B2CC literature were used to generate the conceptual structure map for this study.

In Figure 11, keywords are distributed as points in the two-dimensional space, and as they are more similar in distribution, they are presented as being closer in the conceptual structure map. To determine the most appropriate number of clusters, k = 2, k = 3, and k = 4 were tested. At k = 4, only one element existed within the cluster (Figure 11a), lacking the significance to constitute a distinct cluster [175]. Consequently, using a k-means clustering algorithm where k = 3 in this study yielded coherent and meaningful clusters (Figure 11b). The largest cluster contained 40 keyword dots (blue cluster), while the smallest cluster had only four keywords (green cluster).



(**a**)

Figure 11. *Cont.*



(**b**)

Figure 11. (**a**) Cluster analysis with factorial analysis (k = 4). (**b**) Cluster analysis with factorial analysis (k = 3).

The blue cluster is the largest cluster, with 40 keyword dots. Other keywords can reflect different topics, approaches, or contents in B2CC studies, in addition to the various spectrums of the B2CC domain and their different nomenclatures. The clustering of these keywords indicates that the topics concern "Systemic Barriers to Circularity in Construction and Demolition". This name reflects the wide-ranging challenges, including waste management, supply chain issues, and the complexities of integrating circular economy practices in construction and demolition activities.

The red cluster contains six keywords that highlight challenges regarding "Navigating the Transition to Circular Construction Practices". This name emphasizes the difficulties in shifting toward circular economy practices in the construction industry, encompassing challenges related to awareness, business adaptation, and seizing opportunities.

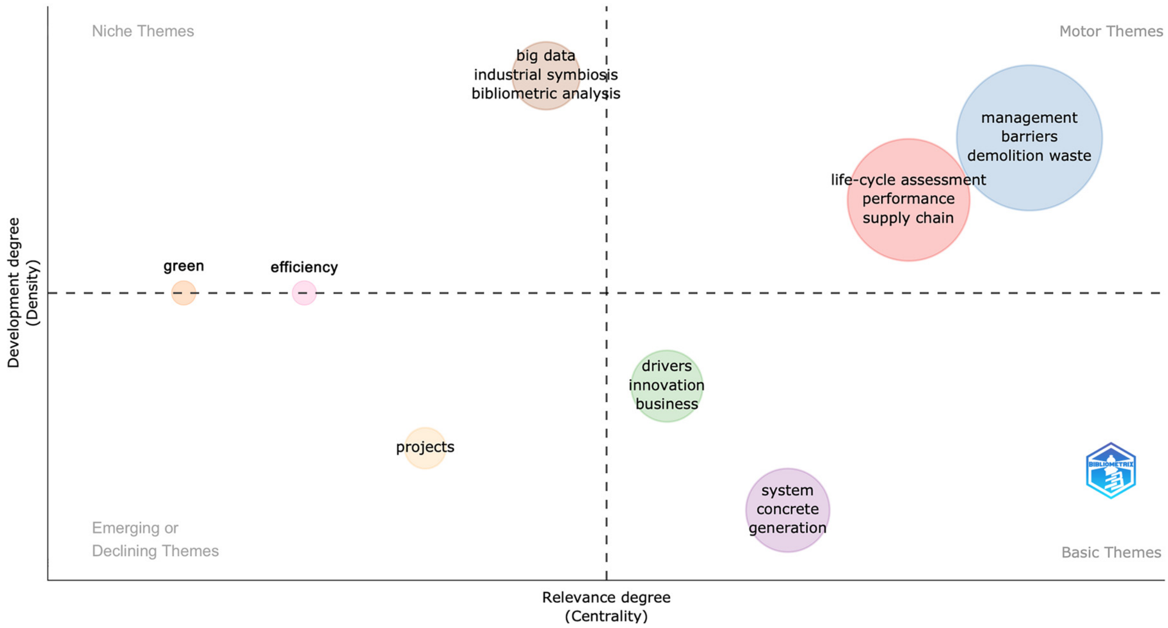
The green cluster involves four keywords and mainly focuses on research into "Barriers to Minimizing Waste through Circular Economy and Reverse Logistics in Construction". The keyword "Shenzhen" appears in this cluster because "Shenzhen" is among the countries of focus for most studies on minimizing waste and reverse logistics.

4.2.6. Thematic Evaluation

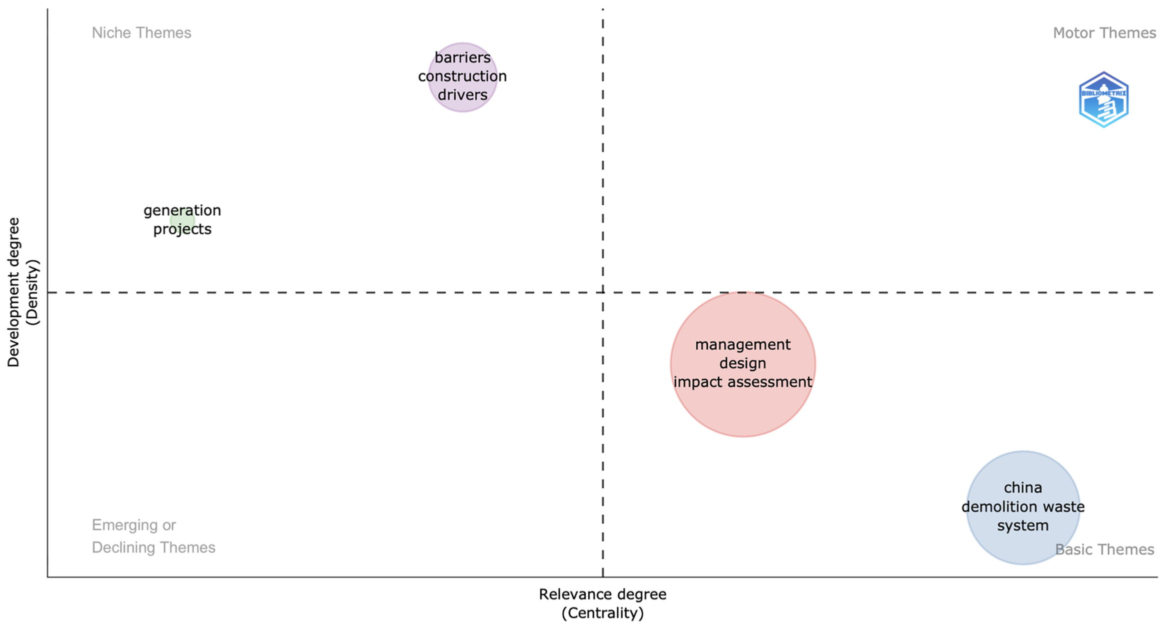
In this sub-section, we analyze the thematic evolution of B2CC research from 2017 to 2024 from a dynamic perspective. Drawing on methodologies from existing studies on thematic evolution [176], we divided the research period into three consecutive sub-periods, each spanning three years, to maintain a consistent and manageable size across the periods. This approach ensured a balanced comparison among the sub-periods. Therefore, the research period from 2017 to 2024 was segmented into the following sub-periods:

2017–2019, 2020–2022, and 2023–2024. Figure 12a–c illustrates the distribution of articles across these sub-periods.

The strategic diagrams of B2CC research in each sub-period are presented in Figure 12a–c, which was constructed using Bibliometrix through co-word analysis utilizing Keywords Plus. Figure 12a–c shows that the themes associated with many publications are primarily located in the fourth quadrant, which is logical since basic and transversal themes are central to the B2CC field. The number of thematic clusters increases throughout the research periods, reflecting the B2CC domain's evolution into a more complex and diverse research area encompassing a wide range of themes.

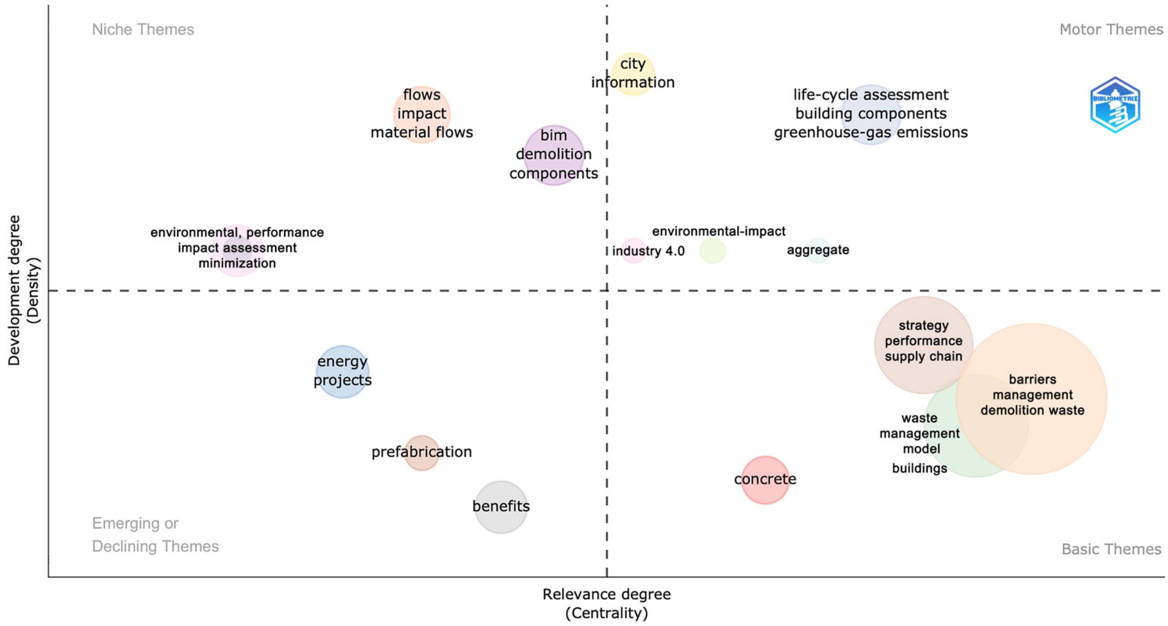


(**a**)



(**b**)

Figure 12. *Cont.*



(**c**)

Figure 12. (**a**) Strategic diagrams of B2CC research (2017–2019). (**b**) Strategic diagrams of B2CC research (2020–2022). (**c**) Strategic diagrams of B2CC research (2023–2024).

A Sankey diagram was constructed to analyze the interactions among theme clusters (as depicted in Figure 13) within a longitudinal framework, identifying the main evolutionary paths of these themes, as shown in Figure 13. In the Sankey diagram, each node represents a theme cluster, labeled by the keyword with the highest frequency and the corresponding sub-period. The size of each node is proportional to the number of keywords associated with that theme. The flow between nodes illustrates the evolutionary trajectory of the theme clusters, with the edge width proportional to the inclusion index between connected themes. A set of themes evolving across different sub-periods can be interpreted as a thematic area. It should be noted that themes without connections to other themes are not displayed in Figure 13.

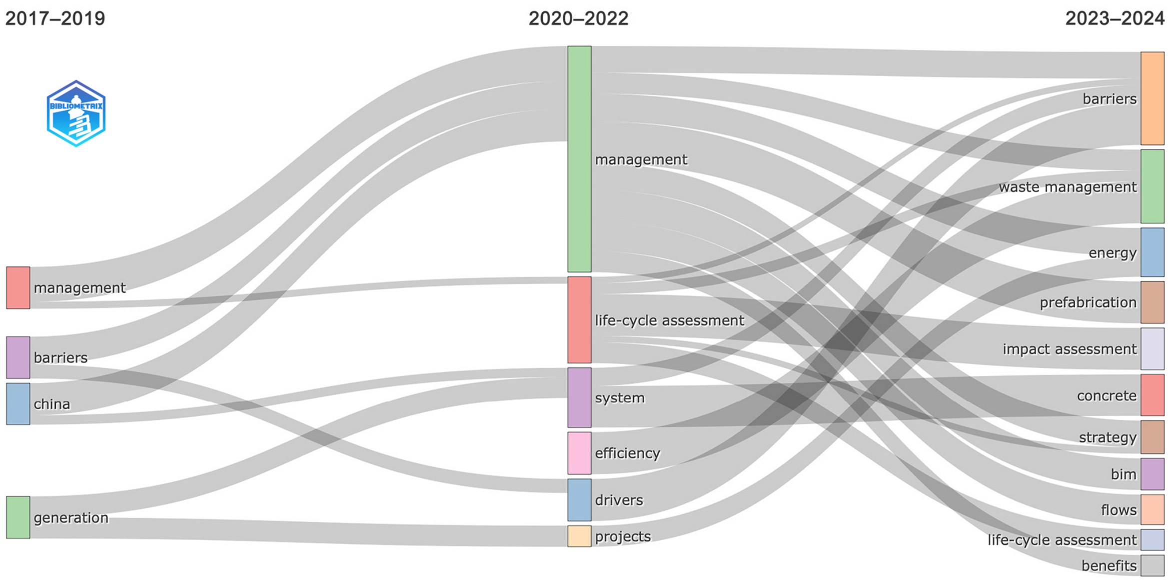


Figure 13. Thematic evolution of B2CC research (2017–2024).

This study examined the evolution of B2CC research across three distinct periods: 2017–2019, 2020–2022, and 2023–2024. Although the topic of the circular economy in construction-related studies began in the early 1980s, studies on the barriers to B2CC were first initiated in 2017. The evolution path of management can be seen in Figure 13 and is summarized in Table 8.

Overall, the number of connections among themes has increased over time. Some themes have stably evolved and developed, and others have gained importance and appeared in the last sub-period.

Table 8. Thematic evaluation of B2CC.

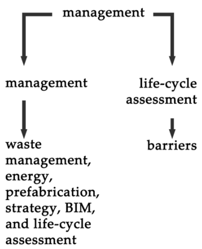
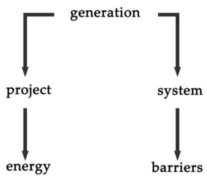
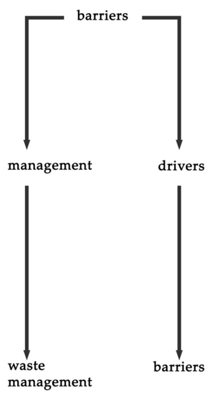
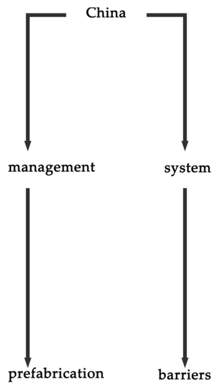
Year Period	Term	Description
2017 - 2019 2020 - 2022 2023 - 2024		"Management" was used as a broad and general term within the context of circular economy challenges. The term "management" remained central but began to transition toward addressing sustainability and efficiency. "Management" evolved into more specific and focused aspects such as barriers, waste management, energy, prefabrication, strategy, BIM, and life-cycle assessment, indicating a more comprehensive and integrated approach.
2017 - 2019 2020 - 2022 2023 - 2024		"Generation" represented a broad concept likely referring to the production or creation of resources or waste. This narrowed to a focus on implementing specific initiatives or projects within the circular economy. It then evolved to highlight energy efficiency and its critical role in sustainability and resource management in the circular economy.
2017 - 2019 2020 - 2022 2023 - 2024		The literature on barriers to circular construction predominantly focused on identifying systemic challenges, such as lack of awareness, regulatory issues, and technical constraints. Initially centered on identifying obstacles to circular construction, the focus expanded to exploring strategies for overcoming these challenges ("management") and recognizing the enabling factors ("drivers") that support the transition to circular practices. This change highlights a move from problem-centric discussions to solution-oriented and opportunity-driven approaches in the field. "Management" became more specialized, emphasizing the operational and practical challenges of handling waste effectively. Simultaneously, the shift from "drivers" back to "barriers" suggests renewed attention to persistent challenges and limitations, possibly highlighting unresolved issues or emerging obstacles in the transition to circular practices.

Table 8. *Cont.*

Year Period	Term	Description
2017 - 2019 2020 - 2022 2023 - 2024		As a global leader in construction and waste generation, China's challenges—such as regulatory gaps, high construction volumes, and limited infrastructure for waste management—served as a focal point for understanding systemic obstacles to circularity. The emphasis transitioned to examining management strategies and systemic frameworks applicable across regions, reflecting a move from localized case studies to global, scalable solutions. The transition from "management" to "prefabrication" suggests growing interest in modular and off-site construction to reduce waste and improve efficiency. Meanwhile, the concept of "system" evolving into "barriers" indicates a deeper exploration of structural and systemic obstacles that continue to hinder the adoption of circular practices, highlighting persistent challenges despite advancements in the field.

4.3. Content Analysis Results

To achieve a more comprehensive evaluation, content analysis was conducted separately for two distinct categories: main topics, and subtopics of barriers to CC. The analysis of the main topics aimed to identify the central themes in the reviewed publications, while the subtopic analysis provided insights into the barriers to CC. The findings from each type of analysis are presented below.

4.3.1. Main Topic Analysis

A content analysis of the circular construction literature would show that there are many themes and geographies being pursued, as shown in Table 9. The prevailing topic was found to be related to the challenges and opportunities linked to the application of CE principles to the construction industry, comprising 43 sources in as many countries, such as Brazil, Saudi Arabia, Taiwan, and some European nations. This means that the nature of the contribution of scholars has been focused on how the circular practices are viable, along with the obstacles and motivators within different economic and regulatory contexts.

Another area has been the investigation of CE practices in the construction sector, as highlighted by 38 sources from Sri Lanka, Ghana, Italy, Luxembourg, and Sweden. Works in this area stress the applicative aspects, case studies, and comparative analyses in order to evaluate the principles of CE in actual construction projects. A closely related strand deals with the impact of applying CE to CDW management: 23 sources have researched resource optimization strategies in the USA, India, China, and Australia. A second set of discourses focuses on the role played by CE in promoting environmental footprints with increasing material recovery.

Developments and applications related to the Circular Construction Evaluation Framework represent another area researched by scholars: 22 sources exploring this theme are from the UK, Europe, and Asia. This strand underlines a growing orientation toward developing common methodologies for the standardized assessment of the degree of circularity in construction projects. To complement this, 13 sources (mainly from Ghana, China, and India) explore the contributions of CE to sustainable development, adding to the linkage between circularity and other broader sustainability goals.

Table 9. Classification of the main subjects.

Rank	Main Topic	Number of Sources	Countries of Papers
1	The challenges and opportunities for implementing or adopting circular economy principles in the construction industry	43	Brazil, Saudi Arabia, Taiwan, Oman, Kazakhstan, Malaysia, Turkey, India, Nigeria, Trinidad and Tobago, Ghana, Sweden, Australia, Netherlands, USA, European countries, China, Chile, Pakistan, UK
2	CE practices in the construction industry	38	Sri Lanka, Ghana, Italy, Luxembourg, Gothenburg, Sweden, Colombia, Chile, Australia, Sri Lanka, Netherlands
3	Impact of CE application on construction and demolition waste/resource management)	23	USA, India, Western Balkans, Colombia, China, Malaysia, Dubai, Australia
4	The development and application of the Circular Construction Evaluation Framework	22	UK, Europe, Serbia, Italy, Japan, Hong Kong, Denmark, United Arab Emirates, Sri Lanka
5	Contributions of CE to sustainable development	13	Ghana, China, India
6	Application of Industry 4.0 and digital transformation toward a CE	12	USA, UK, Hong Kong
7	Adoption of CE in construction	10	Nigeria, Panama, Indonesia, Sri Lanka
8	Strategies for CE	9	Italy, Brazil, Taiwan, United Arab Emirates, Malaysia, Taiwan
9	Critical success factors for implementing a CE	7	Kazakhstan, Hong Kong, Colombia, China
10	BIM in a CE	6	Netherlands, India, Brazil, UK
11	CE Indicators	4	
12	Construction management-based CE	3	Slovakia
12	Development of the circular economy index for the construction industry, using several methods	3	Australia
13	Factors affecting the circularity of building materials	2	Poland
13	Cost of CE	2	Ghana
13	Life cycle assessment of CE	2	Ghana

The emerging themes of circular construction research are: the application of Industry 4.0 and digital transformation (12 sources), the adoption of CE in construction (10 sources), and strategic approaches for CE implementation (9 sources). The integration of BIM into the frameworks of CE has also been addressed, with 6 sources considering the potential of BIM for the optimization of resource efficiency. Besides, research in the field of CE indicators—4 sources—and construction management-based approaches to CE—3 sources—shows a variety of efforts being made toward establishing measurable benchmarks and managerial strategies.

Other specific issues, like the development of the Circular Economy Index for the construction industry, factors affecting the circularity of building materials, cost considerations, and life cycle assessment, are less well-represented, being covered by only two or three sources. Based on these findings, it can be concluded that certain areas regarding circular construction have been documented; however, other areas need further research conducted empirically, which would support both the theoretical and practical perspectives.

The geographical spread of the selected studies shows that CE in construction is a global research concern, with considerable contributions from Europe, Asia, and North America. Other regions, like Africa and Latin America, are relatively less represented and could indicate a gap in the literature of these regions. Generally, this review demonstrates that circular construction is multi-dimensional, including policy, technology, economic, and sustainability aspects that together will define the transition to a circular built environment.

4.3.2. Subtopics of B2CC

A comprehensive analysis of the obstacles related to CC subtopics was conducted to identify the specific variables examined in the documents listed in Table 10. To integrate the results of the scientometric analysis with content analysis, barriers were divided into three sub-categories, as identified in the clustering analysis (Figure 11b) (Section 4.2.5): (1) systematic barriers to CC, (2) navigating the transition to CC practices, (3) barriers to minimizing waste through CE and reverse logistics.

Table 10. Barriers to CC.

Sub-Category	Subfactor	Number of Sources
Systematic Barriers to CC	High expenses for deconstruction, material separation, treatment, transportation, and storage of construction and demolition waste (CDW).	70
	Financial concerns and risk aversion regarding circular business models.	64
	Underdeveloped or missing market systems for material recovery and reuse.	53
	Abundance and affordability of virgin materials.	45
	Absence of national objectives, binding targets, and the supporting legal frameworks.	45
	Absence of reward or penalty mechanisms for CDW management practices.	40
	Rigidity in building codes and regulations.	28
	Ineffective governmental oversight, due to a lack of qualified professionals and budgets.	26
	Lack of producer responsibility systems and integrated resource management regulations.	26
	Lack of legal requirements for a minimum reuse or recycling percentage of CDW.	26
	Absence of taxation frameworks and quality standards for reclaimed materials.	23
	Elevated costs of recycled or reused materials and products.	22
	Lack of a guiding waste code to support CDW management and discourage landfilling.	22
	Significant investment costs associated with waste management technologies.	18

Table 10. *Cont.*

Sub-Category	Subfactor	Number of Sources
Systematic Barriers to CC	Product pricing that excludes environmental costs.	15
	Preference for quick returns on investment and high premiums for green buildings.	13
	Absence of standardized international frameworks for Environmental Product Declarations.	9
	Insufficient land-use zoning and rational urban planning strategies.	7
	High expenses for product certification development.	6
Navigating the Transition CC Practices	Negative public perceptions due to poor communication, a lack of trust, and awareness gaps.	68
	Limited understanding of circular tools like Environmental Product Declarations (EPDs), Material Passports, and certifications.	44
	Lack of tools and guidance for implementing and assessing circular buildings.	41
	Insufficient knowledge of design for disassembly (DfD), green design, and end-of-life strategies for products.	32
	Minimal incentives and support for end-of-life design approaches, including DfD.	18
	Over-reliance on recycling, neglecting other aspects of the waste hierarchy.	13
	Insufficient publicity and awareness campaigns.	12
	Limited implementation of environmental management programs and facilities in academic institutions.	8
	Social and behavioral challenges rooted in modern consumerist habits.	7
Barriers to Minimizing Waste through CE and Reverse Logistics	Insufficient datasets and tools compatible with BIM.	59
	Conservative, competitive, and fragmented supply chain structures.	58
	Recycling hindered by inadequate material separation, logistical constraints, and poor product designs for disassembly.	52
	Poor quality and limited accessibility of data due to issues like privacy, trust, and ownership.	40
	Complexity in material compositions and building structures, including modifications over their lifecycle.	34
	Absence of systems for identifying, classifying, and certifying salvaged materials.	24
	Limited support for research, innovation, information-sharing, and business procurement strategies.	12
	Inefficient management of construction and demolition waste.	11

Table 10. *Cont.*

Sub-Category	Subfactor	Number of Sources
Barriers to Minimizing Waste through CE and Reverse Logistics	Lack of standardized spatial geometries and limited tools for DfD visualization.	8
	Limited consideration of service-oriented purchasing over ownership models.	8
	Insufficient progress in developing effective green building designs.	5
	Challenges in understanding and preparing Environmental Product Declarations.	4
	Lack of thorough documentation for both new and used building products.	4

Systematic barriers to CC fall into broad categories. The most prominent barriers include high deconstruction expenses [50,105,177], financial risk aversion [55,78,89], a weak material recovery market [50,109,112,178], cheap virgin material [179,180], and a lack of legal frameworks [53,99,120,181].

Navigating the Transition to CC Practices. The notable barriers to transition to CC practices include negative public perception [61,80,118,182,183], limited circular tool knowledge [35,184–186], and a lack of implementation guidance [116,177,187–189].

Barriers to Minimizing Waste through CE and Reverse Logistics. The most outstanding barriers in this scope include incompatible BIM datasets [51,52,78,190], fragmented supply chains [89,92,124], and logistical barriers to recycling [77,115,191–194].

5. Discussion

This study draws on an extensive and reliable dataset of 199 research papers focused on the origins of the B2CC, published between 2017 and 2024 and sourced from the Web of Science (WoS) database. Using a quantitative approach, this study explores multiple dimensions, including the annual distribution of publications, key contributing countries, prominent researchers, and leading journals, as well as conducting keyword analysis, thematic evaluations, and trend topic assessments.

5.1. General Information on Trends and Developments in B2CC Research

The extensive body of research on B2CC has steadily increased over time and reached a significant milestone in 2023, marking the peak of publications activity in this field. This surge reflects a growing interest in the subject and its increasing relevance. The increase in academic articles on B2CC can be attributed to several interrelated factors. The notable rise in B2CC research over the past year highlights the topic's critical role in addressing global sustainability challenges [182]. As the current year progresses, the volume of research continues to expand, demonstrating exponential growth in recent years. This trend underscores the heightened focus and urgency surrounding circular economy initiatives (Figure 3).

Australia and China lead in terms of published articles on B2CC, each contributing 24 articles. Australia's leadership is driven by a robust regulatory framework, industry collaboration, and a commitment to innovation [195]. Policies targeting environmental sustainability, including waste reduction and climate action, have been pivotal in transforming the construction sector [196,197]. Additionally, research and development efforts, supported by universities and institutions, have advanced sustainable practices, with strong partnerships between government, academia, and industry driving this transition [198].

Similarly, China has experienced significant growth in B2CC studies, largely due to its government's focus on sustainability. The "*Guiding Opinions on Green and Low-Carbon Circular Development*" and the "*14th Five-Year Plan*" emphasize waste reduction, resource efficiency, and the integration of green technologies in construction [199,200]. China's promotion of green financing, innovation, and inter-organizational collaboration is fostering partnerships between the private sector, academia, and government, much like in Australia, setting the stage for sustained growth in CC [201]. While Australia and China lead in terms of publications volume, other countries like India, Denmark, and Slovakia require more joint initiatives. Spain, however, stands out for its high level of international collaboration, as reflected by its MCP-to-SCP ratio.

5.2. Mainstream Research Topics

Unlike previous studies, this study presents three mainstream research topics related to B2CC, conducting keyword co-occurrence cluster analysis (Figure 11) within the scope of qualitative discussion. The identified clusters and their associated keywords offer a clear delineation of three mainstream research topics and themes within the field: (1) systemic barriers to circularity in construction and demolition, (2) navigating the transition to circular construction practices, (3) barriers to minimizing waste through a circular economy and reverse logistics in construction. Each research topic is discussed below.

5.2.1. Systemic Barriers to Circularity in Construction and Demolition

The transition from traditional linear models in the construction industry to a CE is complex and fraught with systemic barriers. One of the primary challenges lies in regulatory and legislative gaps [202,203]. In many regions, weak environmental legislation and a lack of clear policies around CDWM hinder the widespread adoption of circular practices [42]. With incentives or mandates for recycling and waste reduction, the industry can avoid defaulting to less sustainable methods.

Economically speaking, the high upfront investment costs associated with circular strategies, such as implementing advanced recycling technologies or restructuring supply chains, are significant deterrents [188]. The instability of the secondary materials market complicates long-term profitability and cost-effectiveness for construction companies [178,204]. Additionally, current business models prioritize short-term gains, while circular practices require a longer-term approach to realize financial returns [42]. Without financial support, such as subsidies or tax incentives, circular practices may be inaccessible to many construction companies [99,205].

Technologically, operational barriers are created by a lack of standardized waste treatment technologies and the inconsistent integration of circular processes, such as sustainable deconstruction instead of demolition [162]. The ability to recycle and reuse materials varies greatly, depending on the availability of infrastructure and expertise across different regions and sectors [100].

A further gap in the literature and in practice is the need to understand how these barriers interact across the project lifecycle. Many studies do not adequately analyze how these challenges manifest at various stages—from planning to demolition—and their compounded effects on implementing CE principles [100].

Moreover, social factors such as community engagement, employment conditions, and safety should be considered. For B2CC initiatives to succeed, there must be a broader focus on how these barriers affect the industry and the surrounding communities and workers. This requires the development of frameworks that address social acceptance and support through education, training, and policy measures [206].

In conclusion, the holistic mapping of these systemic barriers—regulatory, economic, technological, and social—is crucial. By addressing these interconnected challenges, CC can transition toward a circular model, reducing waste, reusing materials, and minimizing environmental impact.

5.2.2. Navigating the Transition to Circular Construction Practices

Successfully navigating the transition to CC involves addressing various interconnected challenges. One key barrier is the lack of stakeholder awareness and engagement. Many stakeholders remain unaware of the specific benefits of circular economy practices compared to traditional waste management. As a result, educational initiatives and platforms such as CE incubators are essential for fostering collaboration and spreading awareness [207].

Local authorities and communities play a crucial role in promoting the 3R principles—reduce, reuse, and recycle—by setting examples through construction projects that showcase circular practices [107]. This local-level involvement and digital innovation can streamline resource management and facilitate better collaboration across the value chain.

However, resistance to change remains a significant challenge. Many actors in the construction industry prefer not to adopt circular practices, due to ingrained behaviors and preferences for established processes [107]. To address this issue, targeted awareness campaigns and stakeholder training programs are necessary to highlight circular construction's economic and environmental benefits. Additionally, this shift can generate new job opportunities, further contributing to economic growth in local communities.

Knowledge dissemination is also critical. A lack of technical knowledge, skilled labor, and infrastructure hampers the implementation of circular practices [208,209]. Developing comprehensive training programs and investing in the necessary infrastructure will drive this transition forward [77].

Lastly, market dynamics pose a significant challenge, with low demand for recycled materials and limited pressure from market forces. Shifting consumer behavior and increasing awareness of sustainable products will help drive demand for circular solutions, influencing production and consumption decisions [210,211].

Overcoming these challenges requires coordinated efforts among regulatory bodies, industry players, and local communities. The construction sector can successfully transition to circular practices by fostering collaboration and encouraging innovation, contributing to a more sustainable future [99].

5.2.3. Barriers to Minimizing Waste Through the Circular Economy and Reverse Logistics in Construction

CDWM remains a significant challenge in the CC due to the large volumes of waste produced and the complexity of materials. Reverse logistics (RL), involving the retrieval and reuse of materials at the end of their life cycle, offers a promising solution by maximizing resource utilization and minimizing waste [212]. However, several substantial barriers limit its full-scale adoption in CC.

One key obstacle is the need for more infrastructure when collecting and sorting CDW, including insufficient take-back systems and reverse flow mechanisms in the supply chain [182,213]. The need for on-site sorting equipment leads to off-site processing, reducing efficiency and raising costs [214]. The preference for demolition over deconstruction further hampers circular practices, as demolition does not support material recovery [215]. Establishing regulatory frameworks mandating take-back systems and offering financial incentives could accelerate infrastructure development.

The lack of technical expertise and the limited space and equipment on construction sites complicate deconstruction, which is central to CE models [216]. Additionally, the high end-of-lifecycle costs—such as extra labor, logistics, and equipment—dissuade stakeholders from adopting RL, making landfilling a more attractive short-term option [182,217].

Another challenge is the need for material tracking systems, which are essential for tracing construction materials and facilitating reclamation [213]. While technologies like IoT, digital twins, and BIM-based material passports offer promising solutions, their adoption in CC still needs to be improved [218]. Standardizing digital technologies and implementing legislation for material traceability would improve reclamation, with public–private collaborations developing pilot projects to demonstrate their practicality.

The composite nature of construction materials further complicates recycling, as these materials often require specialized treatment, making the process labor-intensive and expensive [219]. Modular construction and non-composite materials could simplify recycling, while advanced recycling technologies should focus on automating the separation of composite materials.

To overcome these challenges, CC must develop efficient supply chains and RL systems that integrate CE principles. Addressing infrastructural, technical, and financial barriers will enhance material recovery, reduce waste, and promote sustainability.

5.3. Status Quo and Future Research Directions

The primary contribution of this study lies in providing insights into the research subject and substantially assisting in B2CC in the future, associated with the three identified mainstream research topics. Table 11 presents the future research directions for B2CC. These research directions will contribute to overcoming the deep-rooted B2CC and help accelerate the transition to circular construction, providing clear strategies and tools for stakeholders across the industry.

Table 11. Future research directions for B2CC.

Research Topic	Status of Research	Future Research Directions (FRDs)
Systemic Barriers to Circularity in Construction and Demolition	Policy Integration and Governance Structures	• Investigate how different regulatory frameworks, policies, and government initiatives can facilitate or hinder the adoption of circular principles in construction. • Study the effectiveness of existing regulations and the potential for developing international guidelines.
	Supply Chain Collaboration	• Focus on improving coordination among stakeholders in the construction industry, such as architects, contractors, suppliers, and waste managers, to overcome systemic barriers. • Search how circular strategies can be integrated into every stage of the supply chain and how collaboration models can be optimized.
	Digital Transformation and Data Sharing	• Investigate how digital tools like BIM, blockchain, and digital twins can enhance transparency, track materials across the life cycle, and optimize circularity in demolition processes.
	Economic Viability and Market Dynamics	• Explore how market conditions and economic incentives influence the shift toward circular practices, particularly in relation to systemic barriers like high initial costs, long payback periods, and underdeveloped markets for secondary materials.

Table 11. *Cont.*

Research Topic	Status of Research	Future Research Directions (FRDs)
Systemic Barriers to Circularity in Construction and Demolition	Cross-disciplinary Integration	• Focus on collaborative approaches that incorporate social, environmental, and technological perspectives to tackle these barriers holistically.
	Social and Behavioral Aspects	• Explore how systemic barriers related to circular construction affect human behavior, decision-making, and acceptance within the industry. This might include studies on public perception, training, education, and the behavioral changes needed for circularity to be embraced at a systemic level.
Navigating the Transition to Circular Construction Practices	Implementation Pathways and Frameworks	• Investigate the development of practical frameworks that guide the transition from traditional linear models to circular construction. This could involve case studies of successful transitions, identifying key success factors, and developing roadmaps tailored to different types of construction projects and regions.
	Skill Development and Workforce Transformation	• Focus on the skills and training necessary for the construction workforce to adapt to circular practices. • Analyze current education gaps, develop vocational training programs, and assess how to equip professionals with knowledge of circular principles, digital tools, and sustainable construction techniques.
	Technology Adoption and Innovation	• Explore how emerging technologies like additive manufacturing, modular construction, AI-driven design, and smart materials can accelerate the transition to circular practices. • Examine how these technologies reduce waste, improve material efficiency, and transform construction workflows.
	Lifecycle Design and Circular Materials	• Search into how to better design buildings and infrastructure with lifecycle circularity in mind, including material selection, modularity, and adaptability for future uses. • Focus on studies on new circular materials, their availability, and performance in construction.
	Policy and Economic Instruments	• Study the development of policies, incentives, and economic instruments (such as tax benefits, subsidies, or green certification schemes) that can support the shift toward circular construction. • Analyze how different regions or countries are using these tools to encourage circularity and identify gaps in implementation.

Table 11. *Cont.*

Research Topic	Status of Research	Future Research Directions (FRDs)
Navigating the Transition to Circular Construction Practices	Measurement of Circularity and Success Indicators	• Focus on developing standardized metrics, KPIs, or rating systems to measure the degree of circularity in construction practices. • Explore the effectiveness of current metrics and propose new methods to assess the success of circular transitions at various scales—project-, company-, or industry-wide.
	Cultural and Organizational Change	• Investigate the organizational and cultural shifts required within construction firms to fully embrace circularity.
	Pilot Projects and Real-World Applications	• Focus on conducting and documenting pilot projects that test circular construction practices in real-world scenarios. • Examine the outcomes, challenges, and lessons learned from these projects to provide practical insights for broader industry adoption.
	Stakeholder Engagement and Collaboration	• Explore models of multi-stakeholder collaboration, looking at how different actors (government, industry, academia, and civil society) can work together effectively to transition to circular construction. • Investigate the roles, responsibilities, and partnerships required for systemic change.
	Scalability and Replicability	• Focus on how to scale and replicate successful circular construction practices across different sectors and regions. Within this scope, identifying the unique conditions necessary for successful implementation and how these conditions can be adapted to different contexts may be an alternative.
Barriers to Minimizing Waste through Circular Economy and Reverse Logistics in Construction	Optimization of Reverse Logistics Systems	• Concentrate on designing efficient reverse logistics frameworks that streamline the collection, processing, and reintegration of construction waste materials into the supply chain.
	Economic Feasibility and Business Models	• Explore the economic barriers to implementing reverse logistics in construction, including cost-benefit analyses, funding mechanisms, and market dynamics with innovative business models.
	Design for Disassembly and Material Reuse	• Delve into how buildings can be designed for disassembly, reuse, and material recovery at the end of their life cycle.
	Assessment of Environmental and Social Impacts	• Examine the broader environmental and social impacts of implementing circular economy and reverse logistics practices, such as reducing carbon emissions, conserving natural resources, and promoting job creation in the recycling and material recovery industries.

6. Conclusions

This study presents an overview of current research on B2CC through a scientometric analysis, utilizing the recently developed Bibliometrix tool in R and content analysis. The analysis draws on a comprehensive, reliable, and high-quality dataset composed of 199 journal articles published from 2017 to 2024. These publications provide a broad perspective on B2CC research, covering trends in annual publications volume, citation patterns, the most prominent and impactful journals, and the leading researchers and countries. The key findings in this area are summarized below: (1) B2CC studies increased after 2019 and displayed a notable surge in 2023. This result presents a significant evolution in the discourse surrounding CE within the construction industry. This trend suggests a growing recognition of the complexities and barriers to implementing circular principles in construction practices. (2) The citation analysis reveals that the most highly regarded paper in the field of B2CC was authored by Zhang [87] and was published in Science of the Total Environment. (3) Lu W. stands out as the most prolific researcher in this field and is primarily focused on adapting circular economy in construction. He is followed by Antwi-Afari P., Charef R., Ng S.T., and Wuni I.Y.

A keyword analysis was conducted to explore the knowledge structure of the B2CC domain and identify the core components of the knowledge base. This analysis included a list of the most relevant keywords and the top five keywords, with changes in frequency over time, a conceptual structure map, a network co-occurrence analysis with time-based information, a strategic map, keyword clusters, which define the main B2CC, and a Sankey diagram. These methods helped uncover the primary semantic themes embedded within the text data. The thematic evolution within the B2CC field can be observed by examining the current state and historical trends. The key findings can be summarized as follows: (1) in the analysis of high-frequency keywords in the field of B2CC, it was found that the top 10 keywords (according to their frequency) are barriers, management, demolition waste, construction, design, sustainability, China, life-cycle assessment, economy, and waste management. (2) According to the results of the cluster analysis of these high-frequency keywords in the B2CC field, the three main research hotspots include: (i) systemic barriers to circularity in construction and demolition, (ii) navigating the transition to circular construction practices, and (iii) barriers to minimizing waste through circular economy and reverse logistics in construction.

Content analysis provided a classification of the main topics and subfactors of B2CC. This study also proposes three-dimensional future research directions for B2CC.

6.1. Conceptual and Empirical Implications

This study employed a comprehensive methodology to identify the challenges of circular construction, addressing gaps in previous bibliometric analyses that still need to be explored fully in B2CC. The initial phase of the study assessed the average annual number of publications and citations, providing insights into the chronological trends and research developments in this field. This analysis revealed heightened interest, shifting patterns, and evolving focal points over time, offering valuable perspectives to academics and practitioners regarding the dynamic nature of B2CC. Additionally, these findings provided a concise overview of the field's vitality, assisting in evaluating the research momentum and output across different years. This investigation into active countries examined B2CC research within specific national contexts, considering their unique conditions.

The second phase involved a keyword analysis, which further refined the theoretical framework of B2CC and identified the key themes and interconnections shaping the literature. The frequency analysis of keywords highlighted the dominant themes, providing a quantitative understanding of the most prevalent topics in B2CC research over time.

Keyword mapping, through visual representations, illustrated the relationships between various concepts, offering valuable insights into the links among different aspects of B2CC. An examination of temporal keyword patterns revealed the evolving emphasis on specific terms, shedding light on emerging areas of interest within the field. Thematic network analysis, cluster analysis, and thematic evaluation provided a deeper understanding of the identified topics through a more thorough investigation. Cluster analysis enabled a detailed evaluation of three key clusters in B2CC research, offering in-depth insights into the data within specific contexts. This approach systematically organized, classified, and analyzed B2CC research, allowing researchers to build a theoretical foundation for construction management studies. This conceptual contribution enabled a more comprehensive exploration of the subject's complexity. The thematic assessment further explored core topics to enhance our understanding of B2CC risks by analyzing credible evidence, narratives, and diverse perspectives.

6.2. Managerial Implications

This study holds significant relevance for managers and practitioners seeking to address the challenges of circular construction. Architectural, engineering, and construction firms can apply the management and practical insights presented here to develop effective strategies for overcoming these obstacles.

Mitigating systemic barriers to circularity in construction and demolition requires a strategic approach that encompasses economic, educational, regulatory, and technical dimensions. One of the primary managerial implications for overcoming systemic barriers is the need for a robust framework that promotes the circular economy within construction practices. This includes developing circular business models that emphasize resource efficiency and waste minimization. High upfront investment costs and the instability of secondary material markets are significant barriers to implementing circular strategies in C&D waste management. Therefore, managers must focus on long-term projections and cost-effectiveness in their planning to ensure sustainability and profitability. Furthermore, the integration of digital solutions, such as BIM, can enhance waste management practices by providing real-time data and facilitating better decision-making regarding resource recovery. Another critical aspect is fostering a culture of awareness and education among the stakeholders involved in this barrier. This includes contractors, architects, and the general public, who must understand the importance of responsible circular construction. Educational initiatives can help stakeholders recognize the benefits of circular economy principles, thereby driving demand for sustainable practices and materials. By implementing circular business models, fostering stakeholder awareness, advocating for supportive regulations, and investing in innovative technologies, managers can effectively navigate the challenges associated with circular construction practices.

Navigating the transition to circular construction practices requires a comprehensive managerial approach that encompasses business model innovation, stakeholder collaboration, technological integration, and regulatory advocacy. The transition from a linear to a circular economy in the construction sector involves rethinking business models, enhancing collaboration among stakeholders, and integrating innovative technologies. Each of these aspects requires strategic managerial interventions to facilitate a smooth transition. The reconfiguration of business models is essential for fostering circularity in construction. Construction companies should adopt circular business model strategies that emphasize value creation, transfer, and capture. Managers should focus on developing frameworks that support the transition to circular practices, which may involve redefining product life cycles and resource flows. This includes implementing practices that facilitate the reuse and recycling of materials, thereby reducing waste and enhancing sustainability. By adopting a circular business model, organizations can not only improve their environmental performance but also achieve economic benefits through resource efficiency and cost savings. Moreover, collaboration among the various stakeholders is vital in navigating the complexities of circular construction. The dynamics of inter-organizational projects play a crucial role in realizing circular ambitions, as they require coordinated efforts and shared objectives among different actors. Managers should foster partnerships across the supply chain, including contractors, suppliers, and clients, to create a cohesive approach to circularity. This collaborative mindset can help address challenges such as knowledge diffusion and innovation cycles, which are often barriers to effective implementation. By addressing these dimensions, managers can effectively mitigate the barriers to circularity and drive the construction sector toward a more sustainable future.

Minimizing waste through the construction industry's circular economy and reverse logistics requires a comprehensive managerial approach that addresses infrastructure development, stakeholder engagement, regulatory advocacy, and supply chain optimization. Managers must prioritize establishing efficient reverse logistics networks that facilitate the recovery and recycling of materials. This involves investing in facilities that can handle the sorting and processing of C&D waste and developing partnerships with recycling companies to ensure that materials are effectively reused. Additionally, implementing integrated life cycle design approaches can help in planning for waste reduction from the outset of construction projects, ensuring that materials are selected with their end-of-life potential in mind. Stakeholder engagement is another critical factor in overcoming barriers to CC. The construction industry comprises many stakeholders, including contractors, suppliers, clients, and regulatory bodies. Effective communication and collaboration among these parties are essential for promoting circular practices. Managers should facilitate workshops and training sessions to educate stakeholders about the benefits of reverse logistics and circular economy principles, fostering a sustainability culture within the industry. Engaging stakeholders in the decision-making process can also enhance the acceptance of new practices and technologies for waste reduction. Regulatory frameworks play a significant role in shaping the practices of the construction industry. Managers should advocate for policy changes that incentivize waste minimization and the use of recycled materials to mitigate the effect of B2CC. This may include lobbying for tax incentives for companies that adopt sustainable practices or for stricter regulations on waste disposal that encourage recycling and reuse.

By tackling these barriers, managers can facilitate the transition toward more sustainable construction practices and contribute to the broader goals of waste reduction and resource efficiency.

6.3. Limitations of This Research

Despite the great efforts made in this study to significantly contribute to the B2CC literature, it has some limitations, which will be addressed in future research. First, it exclusively analyzed peer-reviewed articles. Future studies may consider other academic publishing formats, such as book chapters. Second, using data from the WoS database could create constraints. Thus, researchers should explore additional databases like Science Direct or Scopus. One other limitation of the study is the exclusion of non-English literature. Future studies could address this limitation by incorporating a broader range of sources, such as non-English documents, conference papers, and book chapters, to provide a more globally inclusive perspective on barriers to circular construction. Finally, the time of publications was used as a criterion for screening the studies included in this study. Papers published earlier than 10 years ago were included to ensure that the studies reviewed are up to date and reflect the latest advancements in the field. However, this approach may limit the scope of the review by omitting older studies that could offer valuable insights; therefore, this is recognized as a limitation of the study. Future research could consider extending the time frame for the inclusion of studies to capture a broader range of perspectives, including older studies that may offer foundational insights or historical context.

Despite these limitations, this study has the potential to inspire researchers and practitioners to further advance both research and practice in B2CC.

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