

Review

# Literature Review on Collaborative Project Delivery for Sustainable Construction: Bibliometric Analysis

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**Abstract:** This paper aims to conduct a bibliometric analysis and traditional literature review concerning collaborative project delivery (CPD) methods, with an emphasis on design-build (DB), construction management at risk (CMAR), and integrated project delivery (IPD) Methods. This article seeks to identify the most influential publications, reveal the advantages and disadvantages of CPD, and determine the most suitable CPD methods for sustainable construction. This research involves the application of bibliometric instruments in R, which is a powerful statistical computing language that can be used to perform complex data analyses and visualizations on bibliographic data to scrutinize academic journals retrieved from the Scopus database. Google Scholar is also utilized for an in-depth analysis as part of this study. Relevant articles are identified and screened for review. Our analysis is grounded on an extensive dataset of 927 journal articles collected from the year 2000 up to September 2023, providing a robust foundation for a comprehensive examination. Citation analysis identified highly cited publications that have significantly influenced the discourse on CPD. The analysis further established the advantages and disadvantages of CPD methods to suggest the most suitable CPD technique for sustainable construction. The results of this analysis offer insights into future directions and opportunities for further research through a comprehensive overview of the existing discourse on the subject. The paper classifies CPD through collaborative contracting, particularly through early contractor involvement (ECI), groups the design-build and construction manager at risk methods under CPD, and aligns their advantages with the critical success factors for sustainable construction in order to select the most suitable CPD technique. This research can serve as a guide for industry professionals, researchers, and policymakers, providing a structured path for collaborative endeavors and facilitating coordinated efforts toward collaborative project delivery methods and sustainable construction.

**Keywords:** integrated project delivery; design-build; construction manager at risk; sustainable construction



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## 1. Introduction

The architecture, engineering, and construction (AEC) industry is in the midst of an evolution in its approach to project delivery. Historically dominated by methods like design-bid-build (DBB), the sector is increasingly exploring integrated approaches that enhance collaboration and streamline processes. This shift emerges from a consensus that integrating people and processes can significantly enhance project performance. Design-build (DB), by definition, is a comprehensive and cohesive strategy in the realm of construction management; the construction manager at risk (CMAR) approach requires the construction manager to complete the project within a pre-established guaranteed maximum price (GMP), covering all aspects of design and construction and taking responsibility for any cost overruns that fall within the project's scope.

Researchers have defined collaborative project delivery (CPD) as a cooperative construction approach that aligns the interests and goals of all stakeholders, who then share

risks and rewards throughout the design and construction process. Although integrated project delivery (IPD) tends to be regarded as CPD, researchers have classified both DB and CMAR as alternative delivery methods, having been recently developed following DBB [1–3]. This paper, however, regards DB and CMAR as examples of the kind of co-operative efforts that characterize CPD, particularly in terms of early contractor involvement (ECI).

ECI principles influence project outcomes in terms of efficiency, cost-effectiveness, and overall project success. DB is similarly commended for its swift delivery, cost-effectiveness, and constructability as a single strategy encompassing both design and construction [4,5]. However, concerns linger about potential compromises in design quality and reduced owner influence [6,7].

CMAR positions the construction manager as both a consultant and a risk-bearing contractor. CMAR is notable for its early risk identification and cost control via the GMP commitment, but there are reservations about potential conflicts of interest (Gransberg and Shane, 2010) [8,9].

IPD, a truly collaborative approach, binds all stakeholders through a multi-party contract. This shared risk–reward system has been proven to enhance project outcomes and stakeholder satisfaction [10]. The transition to IPD is not without challenges, given the profound changes it demands in organizational culture and contractual habits [11].

The literature also provides insights into the efficacy of these methods. For instance, DB's superior cost and schedule performance over DBB have been highlighted by [12]. The benefits of CMAR in mitigating cost overruns and reducing claims have also been noted. Furthermore, the merits of IPD have been underscored in improved outcomes and stakeholder satisfaction [13,14]. However, not everyone in the AEC realm is convinced. Despite success stories with alternative delivery methods like IPD, reservations persist among owners, architects, and contractors, hindering its ubiquitous adoption [15]. The benefits of integration, such as enhanced teamwork and coordination, are undeniable. The degree to which each delivery method fosters integration and its subsequent impact on performance remains an open question [16].

This research, incorporating studies conducted between 2000 and 2023, endeavors to examine the advantages and disadvantages of CPD methods. By offering a comprehensive overview of their benefits and limitations, this paper aims to illuminate the path forward for construction scholars, industry insiders, and policymakers. This study is different from existing research because it classifies collaborative project delivery through collaborative contracting, particularly through ECI, thus addressing the CPD research gap. Approaching DB and CMAR as collaborative project delivery methods, this study aligns their advantages with the critical success factors for sustainable construction. This will be performed using the following research questions: What is the current research landscape and distribution of CPD (IPD, DB, and CMAR) publications from 2000–2023? What are CPD's advantages and disadvantages?

What is the most suitable CPD technique for sustainable construction and the future of collaborative project delivery and sustainable construction?

The review will examine emerging opportunities and threats in collaborative project delivery, focusing on its advantages and disadvantages to identify future research directions. By analyzing recent publications and discussions on collaborative project delivery and technological advancements, we can pinpoint areas that need further exploration. This includes investigating the impact of Artificial Intelligence (AI) in optimizing communication and human relations in project delivery. Additionally, the review will delve into sustainable construction solutions, providing a comprehensive overview of potential research areas in the field of sustainable and collaborative construction.

The structure of this paper is organized in the following manner: Section 2 provides a summary of the relevant literature; Section 3 details the research methodology employed in this study and describes the process of acquiring research data; Section 4 offers a summary and analysis of the current state of the literature, followed by a keyword analysis

to efficiently meet the research objectives set forth in this study; Section 5 explores the implications and interpretations of the findings; Section 6 addresses forthcoming trends and developments in this field; Section 7 encapsulates the key findings and offers concluding remarks.

## 2. Literature Review

### 2.1. Collaborative Project Delivery

CPD methods, such as IPD, DB, and CMAR, have been pivotal in advancing sustainability within the construction industry. CPD brings together essential participants from the start, creating cohesive teams equipped to tackle complex projects [17]. This unity is essential for sustainable construction. CPD's focus on collective expertise and shared objectives aligns with the principles of sustainable construction by reducing waste, optimizing resources, and ensuring accountability throughout the project's lifecycle. These collaborative principles inherent in CPD methods lay the groundwork for the next evolutionary step in construction practices.

The transition from traditional project delivery methods to CPD represents a significant shift towards a more sustainable and integrated construction process. The evolution of CPD has seen a growing preference for shared risk and transparent communication, which are critical for building trust and achieving mutual project goals, as outlined in [18,19]. IPD has been shown to improve project outcomes and reduce waste, as highlighted by Rodrigues and Lindhard (2021), thus contributing to the environmental sustainability of construction projects [20]. This shift towards integrated approaches like IPD underlines the importance of viewing construction projects as holistic entities, a perspective that is crucial for the next aspect of sustainability in construction.

CPD methods like IPD foster a holistic view of the project lifecycle, integrating all stakeholders from inception through to reuse, effectively embodying the cradle-to-cradle philosophy. This integrated approach not only minimizes waste and maximizes resource efficiency during construction but also throughout the building's operational life, maintenance, and eventual deconstruction, paving the way for materials to be repurposed rather than disposed of, as detailed in [21].

### 2.2. Design Build (DB)

The DB project delivery method represents a holistic and integrated approach to construction management. This method is characterized by the consolidation of design and construction services under the umbrella of a single entity, known as the design-builder, who enters into a contract with the project owner [22,23]. The fundamental ethos of this method lies in its single-point responsibility model [22]. Such a model is strategically designed to mitigate risks and reduce overall costs for the project owner. This is achieved by streamlining the process, which inherently enhances efficiency and effectiveness, and by improving communication channels, which are pivotal in ensuring the seamless progression and completion of the project. The DB method, therefore, stands as a testament to the evolving dynamics in project delivery, aiming to optimize outcomes through a collaborative and unified approach.

### 2.3. Construction Manager at Risk (CMAR)

The CMAR method obligates the construction manager (CM) to deliver a project within a guaranteed maximum price (GMP), encompassing both the design and construction phases, while absorbing the risk of cost overruns within the project scope [2,8,24]. CMAR emphasizes the CM's role in risk management, ensuring project delivery within the GMP, a vital cost-control mechanism that enhances budget adherence [2,8]. This approach is notable for its early risk detection and mitigation, with the CM's involvement in the design phase providing critical insights into constructability and cost estimation [7].

The collaborative nature of CMAR fosters a tripartite synergy among the owner, designer, and CM, enhancing decision-making and project performance [25]. Early CM

involvement also introduces flexibility, allowing design changes with minimal impact on the project timeline or budget [2]. However, the CM's dual role as consultant and contractor may lead to conflicts, compromising the alignment of interests and smooth project execution [8]. This duality underscores the owner's crucial role in managing CM–designer interactions, requiring specific construction management skills [11].

Additionally, CMAR can limit competition among trade contractors, with pre-existing CM–subcontractor relationships potentially affecting project quality and costs [26]. This highlights the need for careful management in the CMAR approach to balance efficiency, cost, and quality in construction projects.

#### *2.4. Integrated Project Delivery Method (IPD)*

IPD is a collaborative approach that integrates people, systems, and practices, optimizing project results, increasing value, reducing waste, and maximizing efficiency across all design, fabrication, and construction phases [27,28]. Central to IPD's efficiency is early stakeholder engagement, enabling early issue detection and fostering innovation while reducing misunderstandings and costly design changes [14,29].

IPD promotes transparency in project budgeting and informed decision-making, establishing a culture of shared risk that encourages cooperation over adversarial relationships. This mutual risk management ensures equitable risk and reward distribution [30–32]. However, implementing IPD may require new legal frameworks and contracts, as traditional agreements may not align with its unique requirements [33,34].

Trust is crucial in IPD; its absence can impede collaboration and open communication. Implementing IPD may challenge traditional organizational cultures, necessitating a significant cultural shift [35]. Additionally, IPD's success often depends on advanced technologies like Building Information Modeling (BIM), and organizations lacking these tools or expertise may not fully benefit from IPD [36].

#### *2.5. Sustainability*

Sustainability and sustainable development are defined through various lenses, emphasizing natural resource management, economic growth, employment, environmental protection, and social progress [37]. Sustainability is living harmoniously with the environment, considering both present well-being and future generations' needs [38]. Sustainability is described as a three-legged stool, symbolizing the interconnectedness of the ecosystem, society, and economy. A missing 'leg' signifies instability, underscoring the need for balanced development across these three aspects [38]. In the corporate sector, the triple bottom line expands sustainability to encompass social, environmental, and financial performance [39]. This framework aligns with sustainable development goals, transcending economic value to equally consider environmental and social impacts. Indeed, as Young (1997) and Ding (2008) suggest, sustainability necessitates the integration of individual and collective actions to maintain environmental integrity, economic progress, and social well-being [38,39].

#### *2.6. Sustainable Construction*

Sustainable construction is a transformative building sector approach that encompasses the entire lifecycle, from design to demolition, focusing on reducing environmental impacts through energy-efficient materials, waste reduction, natural resource conservation, and implementing strategies like green building for enhanced economic and environmental benefits [40].

Project delivery methods such as IPD, DB, and CMAR significantly influence sustainability in the construction industry, aligning with life cycle considerations that extend beyond conventional construction boundaries. The British Standards Institution (BSI, 2008) emphasizes that life cycle costs include construction, maintenance, operational, and end-of-life expenses [41]. These sustainable practices enhance occupant comfort and well-being, underlining their growing importance in the industry and contributing to global

environmental sustainability efforts. This perspective on project delivery methods and their relation to sustainability leads to the critical role of life cycle assessment (LCA) in these processes.

LCA is crucial in CPD models, evaluating every phase of a building's life, from raw material extraction to recycling or disposal. This method considers the environmental impacts of all stages, including material extraction, processing, transportation, and installation, as well as deconstruction and material reuse [42]. Despite the early recognition of sustainability's importance in construction, the implementation of sustainability values into construction project management has experienced delays [43].

### *2.7. Benefits of ECI Comparing Case Studies*

Case 1 demonstrates the drawbacks of not incorporating early contractor involvement (ECI) in a medium-scale residential project on the East Coast of the United States. Despite adopting Building Information Modeling (BIM) for design development and modularization, the absence of ECI meant that the design captured geometric and material information but provided little detail about constructability, the construction process, costs, and the supply chain. This lack of contractor input resulted in significant uncertainties, leading to the project's abandonment in favor of a conventional construction approach without prefabrication or Design for Automated Building (DFAB). Conversely, Case 2 highlights the successful implementation of both BIM and ECI in a small-scale health-care project in northern England. The project effectively managed system complexity in manufacturing through post-rationalization and mass customization, reduced assembly complexity through modularization, and minimized interface complexities in manufacture and assembly through prefabrication. This collaborative approach, facilitated by ECI, significantly enhanced project outcomes in sustainable construction, demonstrating the value of integrating contractors early in the design process [44].

### *2.8. Collaborative Delivery Models*

The Behavioral Elements of Collaborative Delivery Models identifies key behaviors essential for the success of collaborative projects. It emphasizes elements like cooperation, defined as the exchange of information for the project's benefit, and collaboration, which entails working together to achieve the best outcomes. Other critical elements include mutual trust, open communication, commitment to common goals, equality, mutual respect, and team integration. These elements are regarded as fundamental to collaborative project models and are often highlighted in relevant literature [45].

In contrast, the Pyramid Model for collaborative project delivery builds on the basic behavioral elements by exploring their interrelationships and the enablers that facilitate these behaviors. This model is structured into a pyramid that outlines the behavioral elements and their connections, identifying both common enablers that support all elements and specific enablers that support particular behaviors. Through a detailed thematic analysis, this model provides a dynamic representation of how different behaviors interact and are supported within the project delivery framework [45].

While both models are designed to enhance the implementation of effective collaborative practices in project delivery, they differ in their approach and complexity. The Behavioral Element Model provides a straightforward listing and definition of key collaborative behaviors. In contrast, the Pyramid Model delves deeper, analyzing the interdependencies among behaviors and the factors that enable them, offering a more comprehensive and interconnected framework. Despite their differences, both models share a focus on essential collaborative behaviors like cooperation and communication, employing analytical methods to foster better understanding and practice in collaborative project environments [45].

### 3. Methodology

This study utilizes an exhaustive bibliometric analysis to explore the CPD field. Bibliometric methods allow researchers to base their findings on aggregated bibliographic data produced by other scientists working in the field and express their scholarly opinions through citation, collaboration, and writing [46]. A traditional literature review methodology is also employed to systematically evaluate the advantages and disadvantages of IDP, DB, and CMAR approaches in relation to their contributions to sustainable construction. This assessment identifies the critical success factors and obstacles faced in sustainable construction practices. Traditional literature reviews strive to compile a great deal of information in an accessible and succinct manner, and they continue to offer a valid way to identify existing patterns and gaps in research [47].

#### 3.1. Research Methods

Bibliometric techniques primarily serve two functions: analyzing performance and mapping scientific domains [48]. Performance analysis gauges the research contributions of scholars and academic bodies, while the purpose of science mapping is to reveal the foundational architecture and evolution of various scientific arenas. Such insights into the organization and progression of fields are invaluable for researchers focusing on specific investigative trajectories. With bibliometric methods, a balanced blend of quantitative precision is integrated into what is typically a subjective review of published works, offering substantiated evidence for theoretical categories within review articles [46]. This analysis is a valuable tool for studying bibliographic materials using quantitative methods and is often used when presenting classified bibliographies [49]. To ensure accuracy and objectivity, certain steps are pre-established through the research protocol, and all possible sources of bias and error that can undermine the relevance of this study are considered [50]. The steps for this study included research design, data collection, data analysis, data visualization, and data interpretation [46], as illustrated in Figures 1 and 2. Presently, several R-based software packages are available for measuring document information [51].

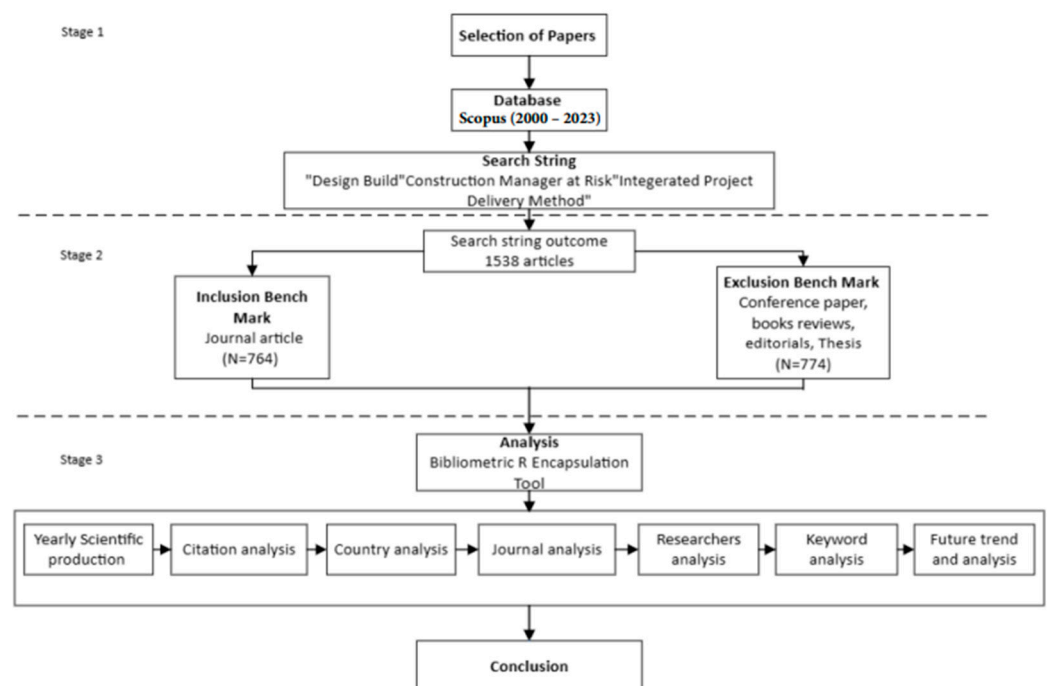


**Figure 1.** Framework of research (Bibliometric analysis).

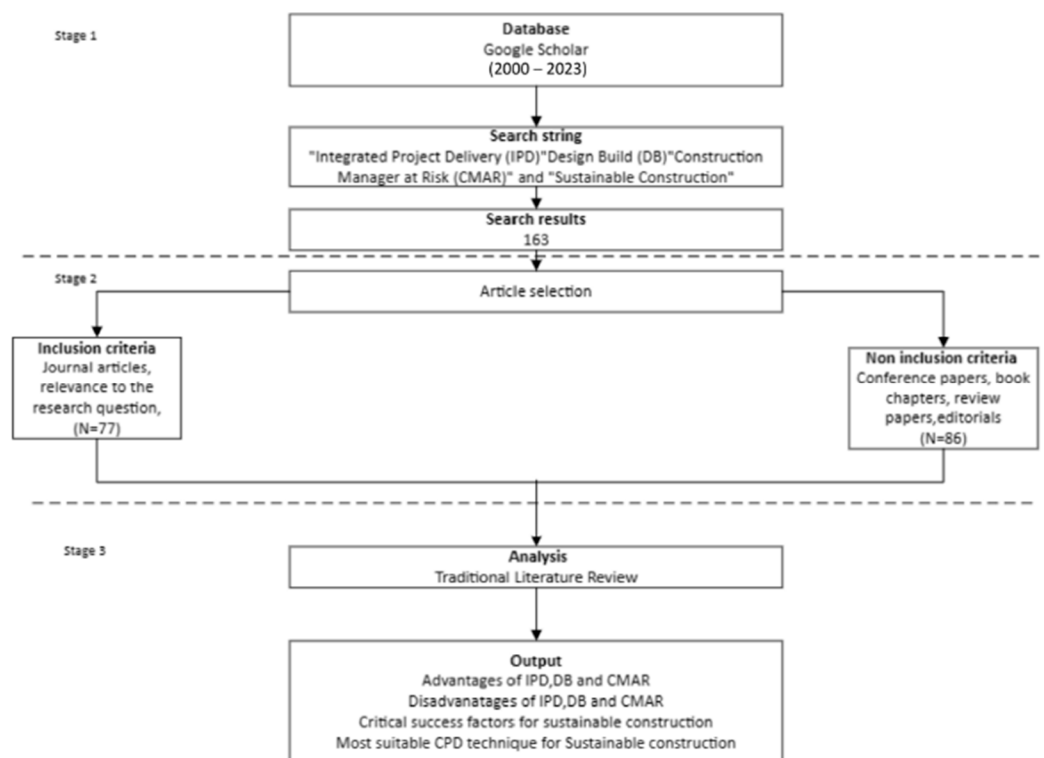


**Figure 2.** Reasons for using Scopus and Google Scholar Databases.

Scopus facilitated the use of Bibliometric analysis using R, which is a powerful statistical computing language used to perform complex data analysis and visualizations of bibliographic data. This helped in measuring productivity, analyzing impact, identifying key authors and institutions, mapping networks, detecting research trends, comparing research output, and understanding publication patterns. Meanwhile, Google Scholar facilitated the traditional literature review, which enhanced the review on the advantages and disadvantages of IPD, DB, and CMAR.

### 3.2. Database Research

This study adopted an analytical methodology using the extensive Scopus database as the primary source for data retrieval. Scopus, a comprehensive repository, comprises records from more than 7000 publishers and offers an archive that spans over 87 million documents, with historical data going back to 1788. Furthermore, it links to affiliations from approximately 94,000 institutions and boasts a rich citation index with roughly 1.8 billion cited references, showcasing its expansive reach.

Following the data collection phase, the next steps included meticulous data extraction and filtering procedures. The adopted search methodology in this investigation resonated with strategies put forth by prominent researchers [52]. The specific search parameters utilized were TS = “Integrated Project delivery”, “Design Build”, and “Construction Manager at Risk”, targeting literature published from January 2000 up to July 2023. The search was finalized in August 2023.

This study narrowed the scope of the literature to focus exclusively on journal articles. This decision is rooted in the consensus that journal articles tend to house research of higher caliber and rigor, often presenting comprehensive insights [52]. From the initial extraction, a total of 1538 publications were identified. However, after a stringent data screening process, a significant number, precisely 774 articles unrelated to IPD, DB, and CMAR, were omitted. Thus, the refined dataset comprised 764 articles, which formed the basis for analysis. A visual representation of this dataset can be gleaned from Figure 3.

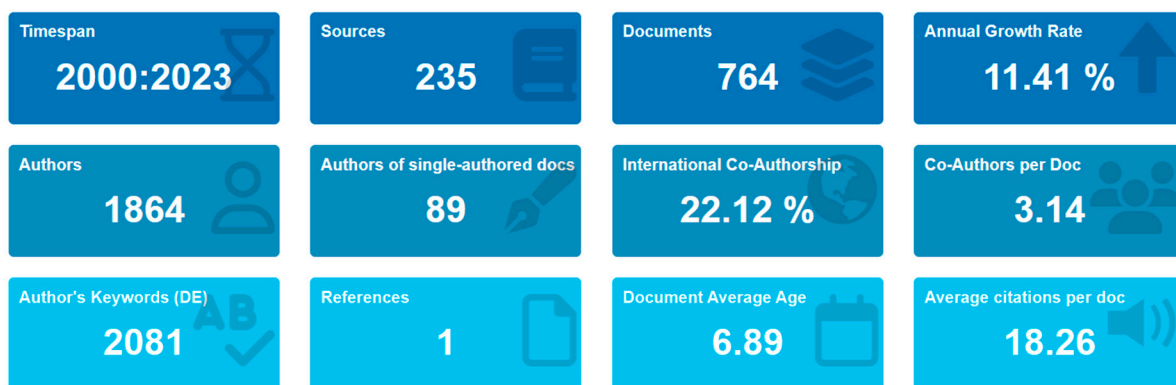


Figure 3. Pivotal information.

## 4. Results

Using several databases for bibliometric analysis was not feasible due to overlapping results and the complexity of comparatively analyzing bibliometric networks [53]. Bibliometric analysis stands as a valuable quantitative method frequently adopted in systematic literature reviews [51]. Drawing upon this technique, global research trajectories concerning the supply chain management of construction projects offer insights into both the prevailing status and emerging prospects [51]. Emulating their methodology, the present study scrutinizes the annual publication count to mark the progression of research on collaborative project delivery (IPD, DB, and CMAR).

### 4.1. IPD, Design-Build, and CMAR Overview

#### 4.1.1. Yearly Publication Distribution of DB CMAR and IPD

The yearly distribution of publications concerning DB, CMAR, and IPD provides a lens through which the evolving academic interest in these areas can be perceived. Analyzing the annual spread of these publications reveals not only the trajectory of research focus but also suggests periods of intensified scholarly activity or potential paradigm shifts in these subjects. The DB methodology saw a growth in research interest during the early 2000s, reflecting the industry's adoption of this approach [18]. Concurrently, a steady rise in CMAR publications starting in the late 2010s is indicative of the method's growing prominence. The trend in research conducted on IPD has increased, particularly in articles examining challenges and documenting growth in IPD-related research since its inception, emphasizing its significance in modern construction project management paradigms [54].

Figure 4 illustrates the yearly dissemination of scholarly articles concerning IPD, CMAR, and DB methodologies. Analyzing this yearly distribution from 2000 to 2023 reveals a compound annual growth rate (CAGR) of 11% in publications, culminating in an apex of publishing activity in 2020. This trend highlights the upward trajectories in research interest and academic contributions within these domains.

Citation analysis (the examination of citation metrics) offers valuable perspectives on the evolutionary patterns, influential capacity, and interdisciplinary resonances of articles in the realm of collaborative project delivery (IPD, DB, and CMAR), specifically within engineering and design disciplines. The 764 papers that fall within the defined time span (2000–2023) contain 14,667 citations. This translates to an annual citation average of 2406.4 for the selected articles. Notably, the article demonstrating the culmination of both total citations (TC) and annualized TC was penned by Kent and Becerik-Gerber. The high citation count of Kent and Becerik-Gerber's article indicates that significant advances have been made in the study of integrated project delivery despite it being the most recent of the three collaborative project delivery methods analyzed in this paper.

Another article that has gained notable recognition is [55]. This article, which compares the two methods from the perspectives of time and cost, found that the design-build was far superior in performance compared to the design-bid-build. The design-bid-build

method has the definitive advantage of saving time. Nonetheless, the project management expertise and experience of the contractor may have a greater impact on project performance outcomes than the project delivery strategies alone [23]. CMAR and DB facilitate better integration compared to competitive delivery methods such as DBB [56]. “Traditional procurement and contracting intentionally serves to isolate designers from contractors to provide checks and balances but limits opportunities for collaboration [16]”. This study found that project delivery methods that included cost transparency with open-book contracts and qualification-based selection of the builder resulted in more cohesive teams and lower average project cost growth, thus demonstrating the benefits of this kind of collaboration. Intriguingly, Table 1 lists the citation statistics of the leading articles, both in terms of absolute citations and annualized metrics.

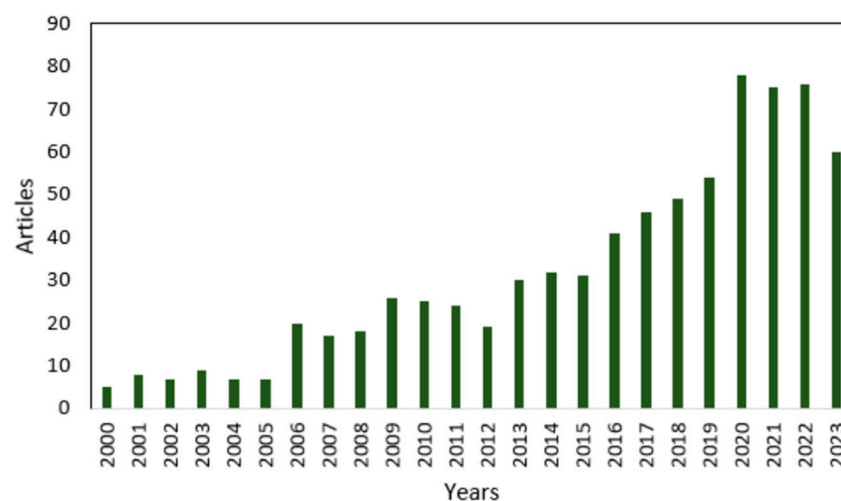


**Figure 4.** Yearly scientific production of IPD, DB, and CMAR.

**Table 1.** Highest overall citation count and annual citation rate.

| Paper                                     | Reference                                | Total Citation TC | TC Per Year | Normalized TC |
|-------------------------------------------|------------------------------------------|-------------------|-------------|---------------|
| Kent D.C., 2010, J Constr Eng Manage      | (Kent and Becerik-Gerber, 2010) [15]     | 300               | 21.43       | 7.67          |
| Ugwu O.O., 2007, Build Environ            | (Ugwu and Haupt, 2007) [57]              | 269               | 15.82       | 7.69          |
| Kines P., 2010, J Saf Res                 | (Kines et al., 2010) [58]                | 238               | 17.00       | 6.08          |
| Asmar M., 2013, J Constr Eng Manag        | (Asmar et al., 2013) [33]                | 226               | 20.55       | 5.01          |
| Ballard G., 2008, Lean Constr J           | (Ballard, 2008) [59]                     | 221               | 13.81       | 6.85          |
| Hale D.R., 2009, J Constr Eng Manag       | (Hale et al., 2009) [55]                 | 211               | 14.07       | 6.95          |
| Bynum P., 2013, J Constr Eng Manag        | (Bynum et al., 2013) [60]                | 185               | 16.82       | 4.11          |
| Ibbs C.W., 2003, J Constr Eng Manag       | (Ibbs et al., 2003) [23]                 | 183               | 8.71        | 8.58          |
| Choudry R.M., 2009, J Constr Eng Manag    | (Choudhry et al., 2009) [61]             | 182               | 12.13       | 6.00          |
| Mollaoglu-Korkmaz S., 2013, J Manage Eng  | (Mollaoglu-Korkmaz et al., 2013) [56]    | 152               | 13.82       | 3.37          |
| El Wardani M.A., 2006, J Constr Eng Manag | (El Wardani et al., 2006) [62]           | 144               | 8.00        | 4.65          |
| Ghassemi R., 2011, Lean Constr J          | (Ghassemi and Becerik-Gerber, 2011) [34] | 143               | 11.00       | 5.54          |

Table 1. Cont.

| Paper                                    | Reference                          | Total Citation TC | TC Per Year | Normalized TC |
|------------------------------------------|------------------------------------|-------------------|-------------|---------------|
| Liu J., 2016, J Constr Eng Manag         | (Liu et al., 2016) [63]            | 140               | 17.50       | 5.12          |
| El-Sayegh S.M., 2015, J Manag Eng        | (El-Sayegh and Mansour, 2015) [64] | 135               | 15.00       | 6.59          |
| Fang C., 2012, Reliab Eng Syst Saf       | (Fang et al., 2012) [65]           | 131               | 10.92       | 4.05          |
| Franz B., 2017, J Constr Eng Manag       | (Franz et al., 2017) [66]          | 126               | 18.00       | 5.56          |
| Kim H., 2016, J Comput Civ Eng           | (Kim et al., 2016) [67]            | 125               | 15.63       | 4.57          |
| Ding L.Y., 2013, Autom Constr            | (Ding and Zhou, 2013) [68]         | 118               | 10.73       | 2.62          |
| Wanberg J., 2013, J Constr Eng Manag     | (Wanberg et al., 2013) [69]        | 116               | 10.55       | 2.57          |
| Shrestha, P.P., 2012, J Constr Eng Manag | (Shrestha et al., 2012) [70]       | 112               | 9.33        | 3.47          |
| Torabi S.A., 2009, Int J Prod Res        | (Torabi and Hassini, 2009) [71]    | 105               | 7.00        | 3.46          |
| Baradan S., 2006, J Constr Eng Manag     | (Baradan and Usmen, 2006) [72]     | 99                | 5.50        | 3.20          |
| Levitt R.E., 2007, J Constr Eng Manag    | (Levitt, 2007) [73]                | 97                | 5.71        | 2.77          |
| Sullivan J., 2017, J Constr Eng Manag    | (Sullivan et al., 2017) [6]        | 93                | 13.29       | 4.11          |
| Araya F., 2021, Saf Sci                  | (Araya, 2021) [74]                 | 92                | 30.67       | 9.5           |

#### 4.1.2. Major Country Analysis

The scholarly articles in this study represent research from 61 nations and regions (Figure 5), with the largest number of publications coming from the USA (584 articles) and China (167 articles). These are followed by the UK (101), Australia (71), South Korea (56), and Canada (51). Developed countries with large populations generally dominate the field and exert the greatest influence on the development of CPD methods; however, developing countries such as Iran and Malaysia have also published a significant number of articles (39 each), while smaller countries such as the Netherlands and New Zealand have also made substantial academic contributions. The broad geographic range of the articles drawn for this study, as well as their diverse demographics, demonstrates the global character of IPD, DB, and CMAR research. (See Table 2).

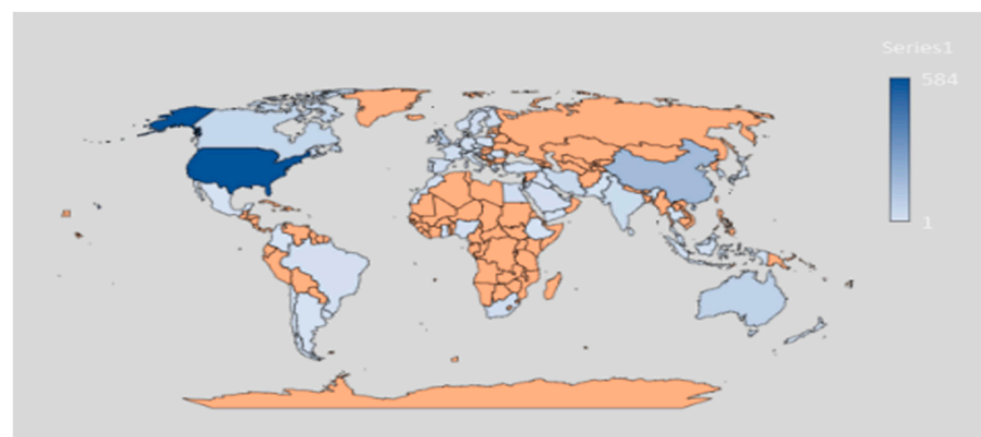


Figure 5. Worldwide publication on IPD, DB, and CMAR (2000–2023).

**Table 2.** Scientific production of countries.

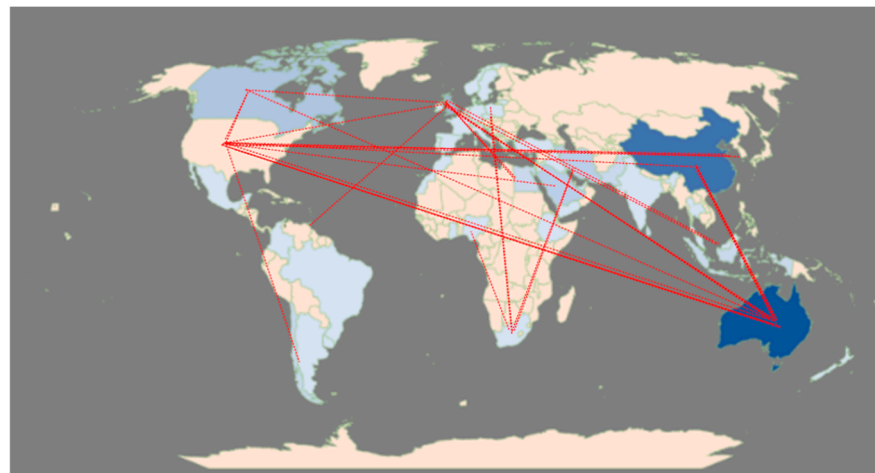
| Country              | Frequency |
|----------------------|-----------|
| USA                  | 584       |
| CHINA                | 167       |
| UK                   | 101       |
| AUSTRALIA            | 71        |
| SOUTH KOREA          | 56        |
| CANADA               | 51        |
| IRAN                 | 39        |
| MALAYSIA             | 39        |
| INDIA                | 30        |
| SOUTH AFRICA         | 22        |
| SPAIN                | 22        |
| FINLAND              | 18        |
| FRANCE               | 17        |
| DENMARK              | 16        |
| EGYPT                | 16        |
| SWEDEN               | 16        |
| INDONESIA            | 15        |
| NETHERLANDS          | 14        |
| NEW ZEALAND          | 14        |
| BRAZIL               | 13        |
| GERMANY              | 13        |
| NIGERIA              | 13        |
| UNITED ARAB ENIRATES | 13        |
| JORDAN               | 12        |
| SAUDI ARABIA         | 12        |

Table 3 shows the total citations (TC) and average article citations in IPD, DB, and CMAR for various nations. The USA has the highest TC (4933), suggesting a strong research influence. China follows with a TC of 1106, demonstrating a significant effect on the field. The UK ranks third in TC, with 763 articles cited on average; Hong Kong, Australia, South Korea, Denmark, and Iran all have strong TC values, highlighting their contributions to collaborative project delivery. Other European nations with high TC values include France, Sweden, Spain, and Portugal, indicating a significant research presence in the region. The United Arab Emirates comes out with a TC of 163 and an average number of article citations of 39.7, demonstrating considerable influence despite a lower publication count. High-TC nations like the United States, China, and the United Kingdom may be prospective collaborators for emerging-impact countries.

The frequency of collaboration between countries in IPD, DB, and CMAR research is shown in Figure 6; the color difference helps to show the regions and countries with more clarity. The most common collaborations are between Australia and China (15), the USA and China (12), Australia and Hong Kong (11), and China and Hong Kong (10). Australia's collaboration with China and Hong Kong shows that Australia is a significant worldwide collaborator. The US and the UK also demonstrate their worldwide engagement by each having partnered with more than 10 different countries individually.

**Table 3.** Most cited countries.

| Country              | TC   | Average Article Citations |
|----------------------|------|---------------------------|
| USA                  | 4933 | 23.70                     |
| CHINA                | 1106 | 18.10                     |
| UNITED KINGDOM       | 763  | 19.10                     |
| HONG KONG            | 703  | 37.00                     |
| AUSTRALIA            | 494  | 21.50                     |
| SOUTH KOREA          | 312  | 16.00                     |
| IRAN                 | 198  | 52.00                     |
| SPAIN                | 191  | 15.20                     |
| SWEDEN               | 188  | 21.20                     |
| PAKISTAN             | 182  | 20.90                     |
| FRANCE               | 164  | 182.00                    |
| UNITED ARAB EMIRATES | 163  | 32.80                     |
| MALAYSIA             | 154  | 32.60                     |
| INDIA                | 145  | 15.40                     |
| SINGAPORE            | 130  | 13.20                     |
| CANADA               | 107  | 43.30                     |
| ITALY                | 92   | 7.60                      |
| LEBANON              | 92   | 18.40                     |
| NETHERLANDS          | 91   | 18.40                     |
| NORWAY               | 74   | 18.20                     |

**Figure 6.** Global map of collaborating countries.

Egypt and the US also collaborate frequently (6), and the collaboration between South Africa and Iran (6) indicates expanding relationships between nations with growing research outputs. The collaboration between South Africa and Nigeria (4) may indicate collaboration in solving particular regional concerns. Collaborations between the United States and the Republic of Korea (8) showcase connections between established and emerging economies. Collaborations between the United Kingdom and the USA (5) may imply collaborations for consolidated expertise.

#### 4.1.3. Most Relevant and Influential Journals

In this study, articles from 235 journals were examined, with Figure 7 highlighting the top 20 journals focused on engineering, design, and construction for CPD.

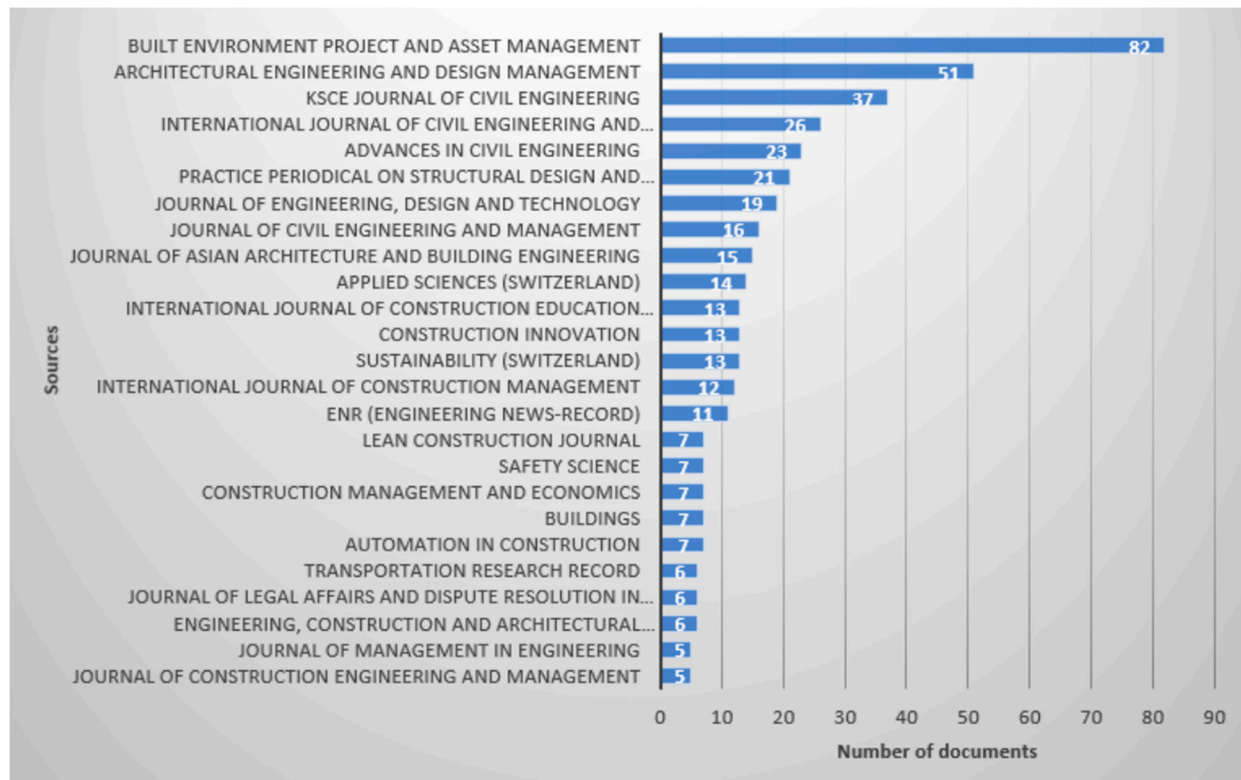


Figure 7. Top 20 journals related to CPD.

The *Journal of Construction Engineering and Management* has grown remarkably since 2018, reflecting the enormous worldwide movement towards better construction and engineering management, as well as collaborative project delivery. The *Journal of Management in Engineering* has also significantly increased its publishing since 2012 due to a greater focus on collaborative project delivery. Other journals related to project delivery have represented similar trends, such as the *Journal of Engineering, Construction, and Architectural Management*, the *Journal of Legal Affairs and Dispute Resolution in Engineering*, the *Journal of Transportation Research*, the *Journal of Automation in Construction*, and the *Journal of Building*. Figure 8 illustrates the consistent rise in research output, notably in the recent decade, which establishes the emphasis on the growing need for collaborative project delivery methods.

#### 4.1.4. Corresponding Author Countries

Some researchers prefer domestic research activities, whereas others prefer international collaborations. A graphical representation of single-country publications (SCP) and multiple-country publications (MCP) for the top 20 contributing countries in the CPD field is given in Figure 9. Researchers in the USA have published the highest number of articles on IPD, DB, and CMAR, most of which are within the country (184), while publications in collaboration with researchers from other countries are significantly fewer (24). China has the second-highest number of papers published domestically (40), and the second-highest number of papers published in collaboration with other countries (21). The United Kingdom comes third with an SCP of 24 and an MCP of 16, while Korea comes fourth with an SCP of 21 and MCP of 3, and Australia is fifth with an SCP of 12) and an MCP of 11.

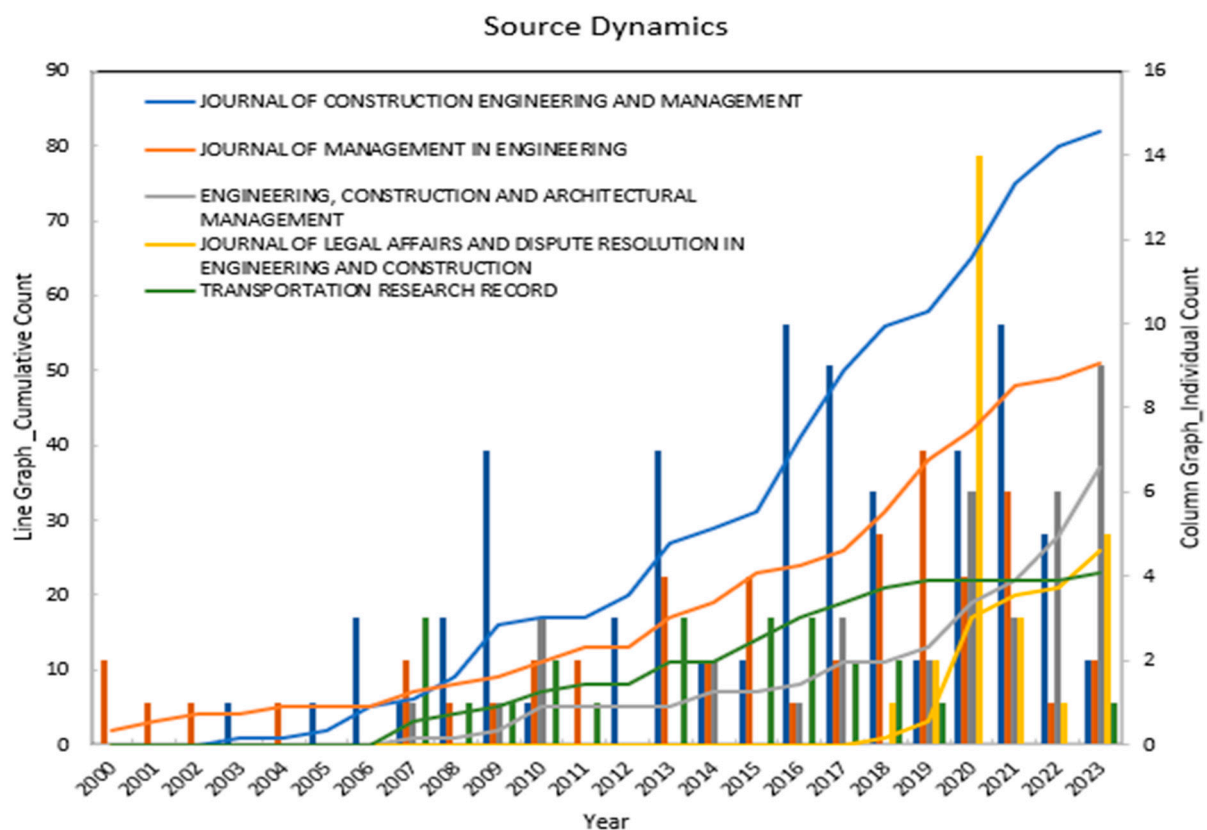


Figure 8. Production of sources over time.

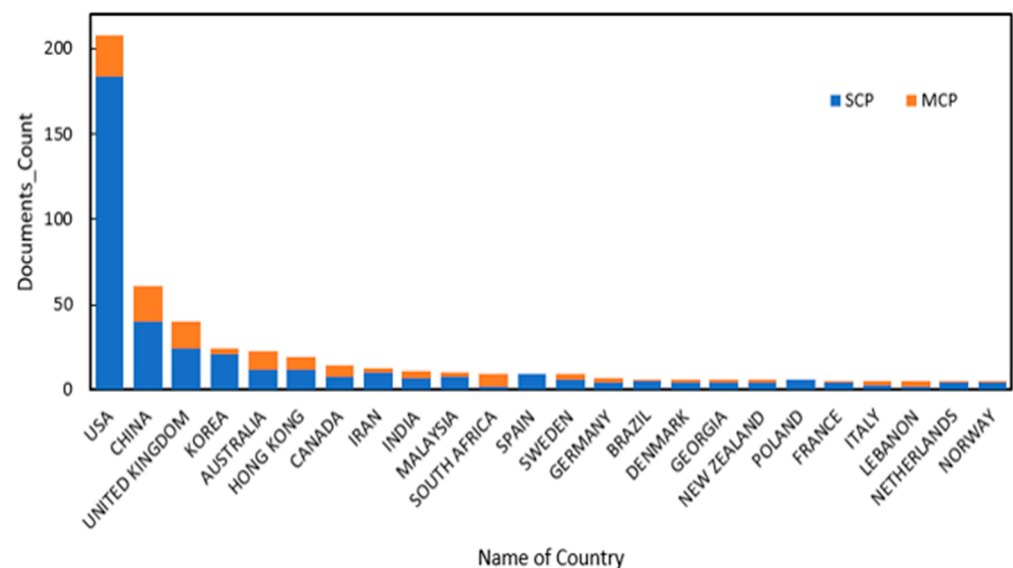


Figure 9. Corresponding authors' countries.

Surprisingly, there is a greater rate of multiple-country publications by Australian researchers (32) than those in the USA, China, and the UK. The MCP ratio is 47.8%, implying that half of the articles published in Australia collaborate with writers from other countries. With higher multi-country partnerships, Australia demonstrates a strategic approach to global research networks. The United Kingdom maintains a well-rounded presence with domestic and international ties. Meanwhile, Australia, Hong Kong, Canada, Iran, India, and South Africa show a growing tendency for international collaboration. On the other hand, Sweden, Germany, Brazil, Denmark, Georgia, and New Zealand promote



The frequent use of “construction industry” stresses the sector’s essential role in encouraging collaborative project delivery, while “risk assessment” underlines the importance of mitigating inefficient project delivery.

#### 4.2.2. Co-Occurrence Network Analysis

The co-occurrence network (Figure 12) of high-frequency keywords in IPD, DB, and CMAR literature presents a dynamic picture of the interplay between key concepts in this domain. The nodes represent individual keywords, while the edges connecting them indicate their co-occurrence patterns. The network is divided into distinct clusters based on keyword similarities, revealing underlying thematic connections.

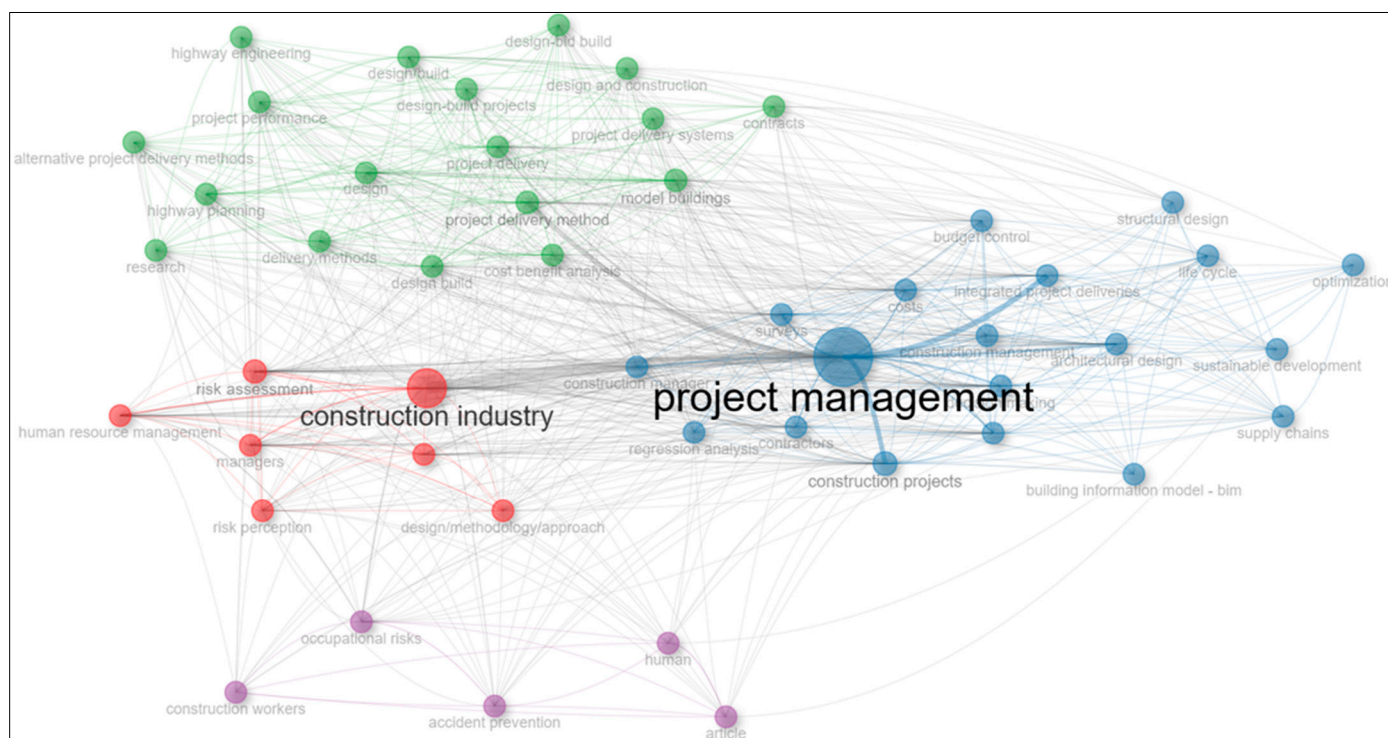


**Figure 12.** Co-occurrence network of high-frequency keywords in CPD.

The first cluster, featuring keywords like “project management”, “contractors”, “construction manager”, “construction management”, “construction projects”, “cost”, and “surveys”, centers around data collection and stakeholder collaboration. This cluster suggests a strong focus on improving data collection and availability for construction execution.

The second cluster encompasses keywords like “construction industry”, “risk assessment”, “risk perception”, “design methodology approach”, and “human resource management”. This cluster highlights design strategy and risk management through the integrated nature of IPD, DB, and CMAR.

The third cluster centers around keywords “construction workers”, “occupational risks”, and “accident prevention”. This cluster highlights the need for health and safety in the engineering, design, and construction phases.

#### 4.2.3. Analysis of Keywords’ Frequency over Time

Figure 13 depicts the cumulative frequency of key terms from January 2000 to July 2023. The analysis shows growth in keywords like “project management”, “construction industry”, “risk assessment”, and “decision making” since the early 2000s. Remarkably, after 2005, the frequency of these terms increased sharply, driven by the need to enhance construction project quality beyond scope, time, and cost. Keywords like “IPD”, “model building”, and “construction projects” became prominent in 2008. Their increasing occur-

rence highlights the growing significance of collaborative project delivery methods, like IPD, DB, and CMAR, in construction design and implementation.

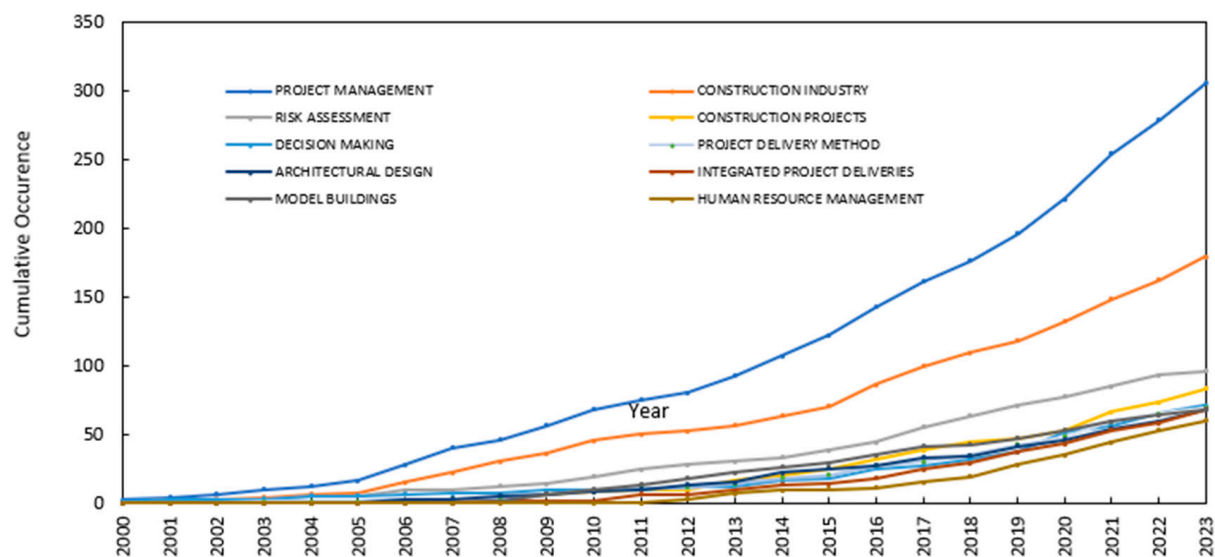


Figure 13. Keyword frequency over time.

The rise in terms like “integration” emphasizes the value of resource integration across disciplines, improving construction project execution. The accelerated frequency of these terms suggests a global acceptance of collaborative project delivery due to its integrative benefits, mitigating scope creep, schedule delays, and project costs.

## 5. Discussion

The analysis presented in Section 4 indicates increasing attention to IPD, DB, and CMAR project delivery methods, especially after 2011. The engineering, design, and construction phases are crucial for these methods’ execution. Figure 14 presents a Sankey diagram illustrating the data flow connections among various components. This diagram includes twenty primary keywords, fifteen journal sources, and fifteen titles. Lines connect titles to their respective keywords, showing article–subject links and journal sources to titles, signifying research publication foci (that is, the specific areas of research that each journal focuses on). Line widths depict the flow intensity between categories.

Prominent keywords, based on line width, include “project management”, “construction industry”, “design build”, “integrated project delivery”, and “engineering”. Notably, the titles “construction”, “project”, and “projects” are closely linked to all 20 keywords, particularly “IPD”, “design-build”, and “integrated project delivery”. The titles “delivery” and “integrated” are also significant, connecting to various keywords. The *Journal of Cleaner Production, Sustainability* and the *Journal of Building Engineering* emerge as top sources. The “design” and “construction” keywords have strong incoming and outgoing flows, while “engineering” ranks fifth in flow intensity.

In essence, the diagram depicts interconnected research themes in the field, highlighting the multifaceted nature of collaborative project delivery, encompassing design, engineering, and construction.

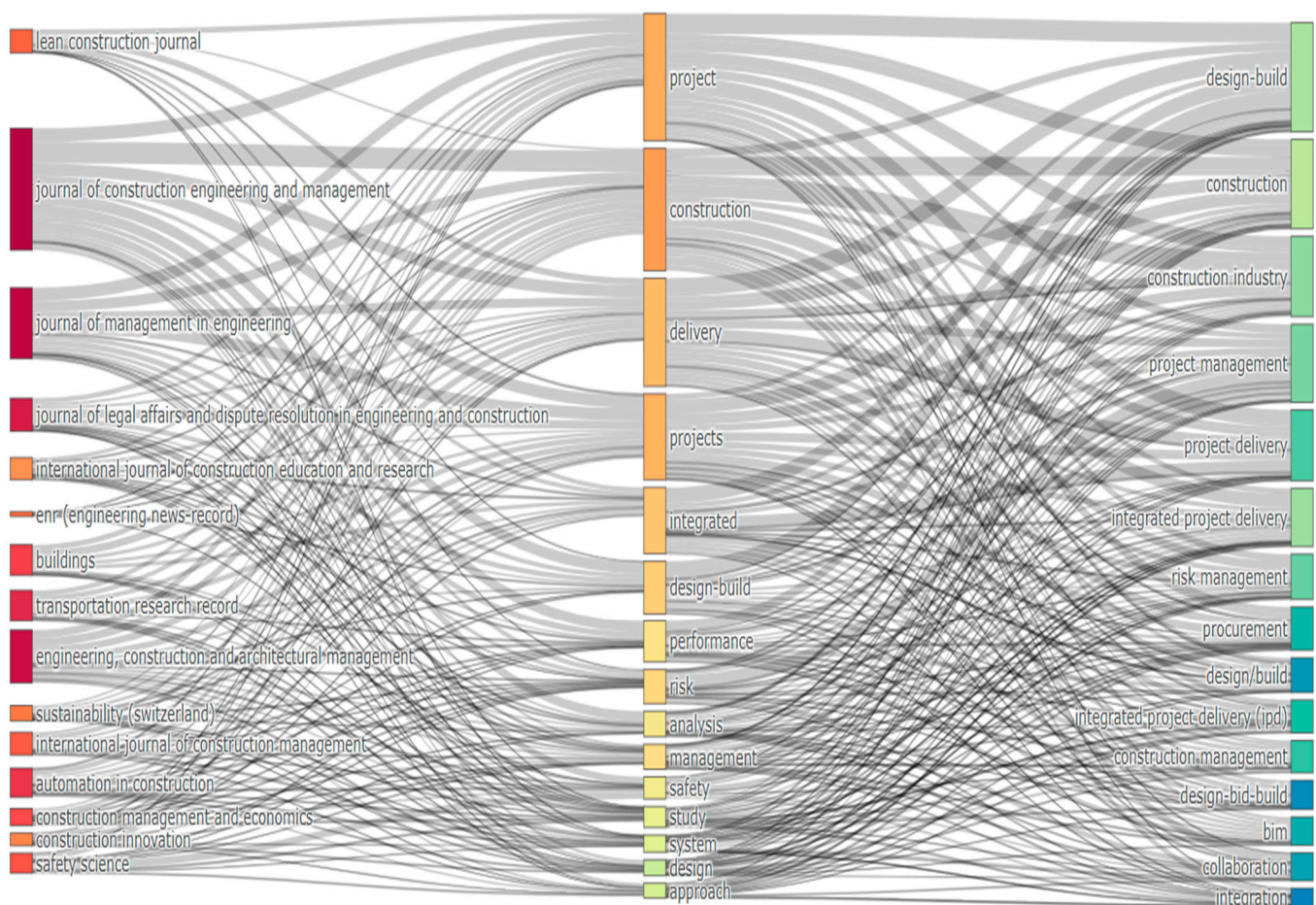


**Figure 14.** Sankey diagram showing connections between titles, keywords, and sources.

### 5.1. Findings of Advantages and Disadvantages of IPD, DB, and CMAR for Sustainable Construction

The findings highlight the comparative advantages and disadvantages of Integrated Project Delivery (IPD), Design-Build (DB), and Construction Manager at Risk (CMAR) methodologies in the context of construction projects. Each delivery method thus presents unique opportunities and challenges for advancing sustainable construction, necessitating careful selection based on project-specific sustainability objectives.

#### 5.1.1. Advantages of IPD

An analysis of 24 (100%) journal articles in the realm of construction engineering and management, as represented in Table 4, reveals significant insights into the advantages of IPD and their importance. The collaborative atmosphere and fairness, which were highlighted in 79% of the articles, emerge as a key topic. This facilitates benefits like reduced schedule time and construction waste, which hinges on the equitable sharing of costs, risks, rewards, and responsibilities, and supports early stakeholder involvement [28,30,76]. The early involvement of stakeholders, noted in 63% of the articles, underscores the importance of stakeholder engagement from the early stages for alignment and success. The use of multi-party agreements and non-competitive bidding in IPD encourages a team-based approach [14,29]. Multi-party agreements help promote trust, and although promoting trust has been mentioned less frequently, with 25%, it is recognized as crucial for nurturing effective team dynamics. The focus on project efficiency is evident, with both reduction in schedule time and reduction in waste receiving 42% mentions each, showing a dual emphasis on timely completion and sustainability. Shared costs, risks, rewards,

and responsibilities, discussed in 75% of the 24 articles, emphasize collaborative risk and benefit sharing.

**Table 4.** IPD advantages.

| IPD Advantages                                                                 |                                                             |                                                                                                                                                                                              |
|--------------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advantages                                                                     | % Percentage of Advantages from Ordered List of Publication | Publication List                                                                                                                                                                             |
| Collaborative atmosphere and fairness                                          | 79                                                          | B = [77] C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] K = [79] L = [83] M = [84] N = [85] O = [86] P = [87] Q = [66] R = [30] S = [14] T = [29] U = [27] V = [35] |
| Early involvement of stakeholders                                              | 63                                                          | B = [77] C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] L = [83] M = [84] N = [85] O U = [27] V = [35] W = [88]                                                     |
| Promoting trust                                                                | 25                                                          | R = [30] S = [14] U = [27] V = [35] W = [88] X = [28]                                                                                                                                        |
| Reduce schedule time                                                           | 42                                                          | C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] S = [14] T = [29]                                                                                                    |
| Reduce waste                                                                   | 42                                                          | C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] S = [14] T = [29]                                                                                                    |
| Shared cost, risk reward, and responsibilities                                 | 75                                                          | C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] S = [14] T = [29] U = [27] V = [35] W = [88] X = [28]                                                                |
| Multi-party agreement and noncompetitive bidding                               | 54                                                          | C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] K = [79] N = [85] Q = [66] T = [29] V = [35]                                                                         |
| Integrated decision-making for designs and shared design responsibilities      | 38                                                          | C = [78] D = [79] E = [36] H = [80] I = [81] J = [82] L = [83] P = [87] T = [29]                                                                                                             |
| Open communication and time management                                         | 38                                                          | D = [79] E = [36] F = [32] O = [86] R = [30] S = [14] T = [29] U = [27] V = [35]                                                                                                             |
| Reduce project duration and liability by fast-tracking design and construction | 25                                                          | F = [32] G = [33] L = [83] O = [86] S = V                                                                                                                                                    |
| Shared manpower and changes in SOW, equipment rentage, and change orders       | 17                                                          | A = [89] F = [32] G = [33] Q = [66]                                                                                                                                                          |
| Information sharing and technological impact                                   | 38                                                          | A = [89] D = [78] G = KLMPRV                                                                                                                                                                 |
| Fast problem resolution through an integrated approach                         | 21                                                          | B = [77] C = [78] D = [79] E = [36] S = [14]                                                                                                                                                 |
| Lowest cost delivery and project cost                                          | 33                                                          | A = [89] C = [78] F = [32] G = [33] L = [83] P = [87] Q = [66] S = [14] T = [29] U = [27]                                                                                                    |
| Improved efficiency and reduced errors                                         | 29                                                          | B = [77] C = [78] F = [32] L = [83] Q = [66] S = [14] T = [29]                                                                                                                               |
| Combined risk pool estimated maximum price (allowable cost)                    | 17                                                          | A = [89] L = [83] P = [87] Q = [66]                                                                                                                                                          |
| Cooperation innovation and coordination                                        | 46                                                          | CEFLPQRSTUV                                                                                                                                                                                  |

Table 4. Cont.

| Advantages                                                                                                                                                                                                                                          | IPD Advantages                                              |                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                                                                                                                                                                     | % Percentage of Advantages from Ordered List of Publication | Publication List                                               |
| Combined labor material cost estimation, budgeting, and profits                                                                                                                                                                                     | 25                                                          | A = [89] D = [79] P = [87] S = [14] T = [29] U = [27] V = [35] |
| Strengthened relationship and self-governance                                                                                                                                                                                                       | 17                                                          | C = [78] D = [79] F = [32]                                     |
| Fewer change orders, Schedules, and request for information                                                                                                                                                                                         | 21                                                          | L = [83] O = [86] Q = [66] T = [29] V = [35]                   |
| Ordered list of publication A = [89] B = [77] C = [78] D = [79] E = [36] F = [32] G = [33] H = [80] I = [81] J = [82] K = [79] L = [83] M = [84] N = [85] O = [86] P = [87] Q = [66] R = [30] S = [14] T = [29] U = [27] V = [35] W = [88] X = [28] |                                                             |                                                                |

Furthermore, IPD's advantages extend to shared manpower allocation, equipment rental, and effective management of changes in the scope of work (SOW) [27,35]. It also emphasizes information sharing and technology for fast problem resolution and optimal project costs [76,77,87].

A preference for cooperative agreements is indicated by multi-party agreements and non-competitive bidding being mentioned in 54% of the articles, suggesting a shift away from traditional competitive methods. Integrated decision-making for designs and shared design responsibilities, as well as open communication and time management (both mentioned in 38% of the articles), points towards integrated, collaborative approaches and the importance of transparency. The interest in expediting project timelines is reflected by the fact that reducing project duration and liability through fast-tracking processes is mentioned in 25% of the articles. These insights from scholarly work underscore the advantages of IPD in sustainable construction, promoting a culture of collaboration and trust [36,66].

A combined risk pool with an estimated maximum price under IPD encourages prudent financial management and fosters innovation, cooperation, and coordination, leading to fewer change orders, more efficient schedules, and reduced requests for information, thereby enhancing the sustainability and prosperity of the construction industry [14,28,30].

#### 5.1.2. Advantages of Design-Build

An analysis of 23 (100%) journal articles on design-build project delivery methods in construction management highlights several key advantages. (See Table 5). This approach, mentioned in 39% of the articles, shows a single point of accountability for design and construction, streamlining project responsibilities and decision-making. DB is a streamlined method and has the significant advantage of assigning responsibility to one entity, which leads to efficient communication and time-saving schedules [7,90,91]. The fact that time-saving schedules are mentioned in 52% of the articles suggests that consolidated roles lead to more efficient timelines. Delivering cost-efficient project solutions, also cited in 39% of the articles, underlines the financial benefits of the DB method.

**Table 5.** Design-build advantages.

| DB Advantages                                                                                                                                                                                                                                 |                                                            |                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Disadvantages                                                                                                                                                                                                                                 | %Percentage of Advantages from Ordered List of Publication | Publication List                                                                                                        |
| Single point of accountability for the design and construction                                                                                                                                                                                | 39                                                         | CDIJMOQRT C = [92] D = [21] I = [93] J = [94] M = [5] O = [95] Q = [90] R = [91] T = [7]                                |
| Produces time saving schedule                                                                                                                                                                                                                 | 52                                                         | CDHJKLMORSTV C = [92] D = [21] H = [96] J = [94] K = [97] L = [98] M = [5] O = [95] R = [91] S = [99] T = [7] V = [100] |
| Cost effective projects                                                                                                                                                                                                                       | 39                                                         | CKLMNOPQSV C = [92] K = [97] L = [98] M = [5] N = [4] O = [95] P = [101] Q = [90] S = [99] V = [100]                    |
| Design build functions as a single Entity                                                                                                                                                                                                     | 8                                                          | DF D = [21] F = [22]                                                                                                    |
| Enhances quality and mitigates design errors                                                                                                                                                                                                  | 21                                                         | F = [22] J = [94] S = [99] V = [100] W = [102] F = [22]                                                                 |
| Facilitates teamwork between owner and design builder                                                                                                                                                                                         | 30                                                         | J = [94] N = [4] P = [101] S = [99] U = [103] V = [100] W = [102]                                                       |
| Insight into constructability of the design build contractor (Early involvement of contractor)                                                                                                                                                | 13                                                         | H = [80] I = [81] T = [29]                                                                                              |
| Enhances fast tracking                                                                                                                                                                                                                        | 4                                                          | R = [30]                                                                                                                |
| Good coordination and decision-making                                                                                                                                                                                                         | 27                                                         | C = [78] D = [21] E = [86] M = [5] O = [86] Q = [90]                                                                    |
| Clients' owner credibility                                                                                                                                                                                                                    | 13                                                         | A = [97] C = [92] G = [104]                                                                                             |
| Dispute reduction mitigates disputes                                                                                                                                                                                                          | 21                                                         | B = [105] H = [96] I = [93] J = [94] Q = [90]                                                                           |
| Ordered list of publication A = [97] B = [105] C = [92] D = [21] E = [86] F = [22] G = [104] H = [96] I = [93] J = [94] K = [97] L = [98] M = [5] N = [4] O = [95] P = [101] Q = [90] R = [91] S = [99] T = [7] U = [103] V = [100] W = [102] |                                                            |                                                                                                                         |

Clients benefit from the cost-effectiveness of design-build projects, which minimize unexpected expenses and enhance quality [90,100]. Enhancing quality and mitigating design errors (mentioned in 21% of the articles) and facilitating teamwork between the owner and the design-builder (mentioned in 30%) emphasize quality assurance and collaborative advantages. Discussion of constructability and enhancing fast tracking, included in 13% and 4% of the articles, respectively, recognize the importance of early contractor involvement and overlapping project phases in timeline reduction. This collaborative dynamic allows for early insight into constructability, better-informed decisions, and the potential for fast-tracking projects without compromising quality [7,104]. Good coordination and decision-making (mentioned in 27% of the articles) and client-owner credibility (13%) support the idea that design-build leads to streamlined and efficient management and client satisfaction. Furthermore, effective coordination and decision-making increase client-owner credibility, often exceeding expectations [106].

These findings paint the design-build method as a preferred strategy in construction project management, known for its time and cost efficiencies, quality improvement, and collaboration. The role of the design-builder as a single entity simplifies interactions, leading to efficient project management [22,23]. Additionally, the reduction in disputes is a notable advantage of design-build, as the single responsibility model inherently reduces potential conflicts, promoting a harmonious project environment. These benefits collectively underscore the design-build approach's advantages for sustainable construction.

### 5.1.3. Advantages of Construction Manager at Risk

Table 6 illustrates the advantages of CMAR in a comprehensive analysis of 16 (100%) journal articles on construction engineering and management. The key advantages are identified as crucial for enhancing efficiency and effectiveness. Early stakeholder involvement, mentioned in 31% of the articles, emphasizes the importance of engaging stakeholders early to align project goals and expectations [8]. Fast-tracking for cost savings and delivery within budget, discussed in 50% of the articles, highlights the importance of expediting project timelines for financial efficiency while maintaining quality [107]. Reducing project duration through fast-tracking design and construction [8], though in only 6% of the articles, aligns with this efficiency goal.

**Table 6.** Construction manager at risk advantages.

| CMAR Advantages                                                                                                                                                                 |                                                               |                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Advantages                                                                                                                                                                      | Percentage of Advantages from the Ordered List of Publication | Publication List                                                                                                    |
| Early stakeholder involvement                                                                                                                                                   | 31                                                            | H = [24] I = [108] L = [7] M = [107]<br>O = [109]                                                                   |
| Fast-tracking cost savings and delivery within budget                                                                                                                           | 50                                                            | A = [110] B = [111] C = [9] D = [25]<br>F = [11] I = [108] M = [107] O = [109]                                      |
| Reduce project duration by fast-tracking design and construction                                                                                                                | 6                                                             | C = [9]                                                                                                             |
| Clients have control over the design details and early knowledge of costs                                                                                                       | 50                                                            | B = [111] C = [9] D = [25] H = [24]<br>I = [108] K = [112] M = [107] P = [100]                                      |
| Mitigates against change order                                                                                                                                                  | 50                                                            | A = [110] C = [9] E = [26] H = [24]<br>I = [108] K = [112] M = [107] P = [100]                                      |
| Provides a GMP by considering the risk of price                                                                                                                                 | 31                                                            | A = [110] B = [111] C = [9] M = [107]<br>O = [109]                                                                  |
| Reduces design cost and redesigning cost                                                                                                                                        | 25                                                            | C = [9] D = [25] E = [26] H = [24]                                                                                  |
| Facilitates schedule management                                                                                                                                                 | 75                                                            | B = [111] C = [9] D = [25] E = [26] F = [11]<br>G = [8] H = [24] I = [108] J = [113]<br>K = [112] M = [107] N = [6] |
| Facilitates cost control and transparency                                                                                                                                       | 69                                                            | C = [9] D = [25] E = [26] F = [11] G = [8]<br>H = [24] I = [108] J = [113] K = [112]<br>M = [107] N = [6]           |
| Single point of responsibility for construction and joint team orientation for accountability                                                                                   | 44                                                            | A = [94] B = [15] E = [34] F = [11] I = [108]<br>M = [107] N = [6]                                                  |
| Facilitates Collaboration                                                                                                                                                       | 25                                                            | E = [26] F = [11] I = [108] J = [113]                                                                               |
| Ordered list of publication A = [110] B = [111] C = [9] D = [25] E = [26] F = [11] G = [8] H = [24] I = [108] J = [113] K = [112] L = [7] M = [107] N = [6] O = [109] P = [100] |                                                               |                                                                                                                     |

Client involvement in design details and early cost knowledge, cited in 50% of the articles, points to a client-centric project management trend, indicating that clients benefit from control over design and early cost knowledge, which enables informed decisions [9,25,111]. Mitigating change orders, also mentioned in 50% of the articles, reflects the focus on minimizing project alterations and their costs, which in turn streamlines construction and reduces delays (Shrestha et al., 2020; [109] et al., 2016) [2,8]. Providing a guaranteed maximum price (GMP), considering price fluctuation risks and discussed in 31% of the articles, shows the emphasis on financial predictability and risk management [8,9]. Reducing design and redesigning costs, covered in 25% of the articles, further highlights its ability to reduce design costs and optimize financial efficiency [9,25,26].

Facilitating schedule management, the most frequently mentioned practice (75% of the articles), is critical to project success, enhancing cost control and transparency and fostering a collaborative environment [6]. Facilitating cost control and transparency, mentioned in 69% of the articles, addresses the importance of financial management and open communication about costs. A single point of responsibility for construction and joint team orientation for accountability is mentioned in 44% of the articles, emphasizing streamlined management and collective responsibility. Facilitating collaboration is discussed in 25% of the articles, which underscores the growing focus on cooperative approaches. CMAR centralizes responsibility, simplifies construction engineering and management, and promotes a joint team orientation, enhancing accountability and success [107,108]. The CMAR model's emphasis on collaboration leverages diverse expertise, making it invaluable for complex modern construction projects [25,113].

#### 5.1.4. Disadvantages of IPD

In a detailed analysis of 12 (100%) journal articles on IPD within construction engineering and management, Table 7 illuminates the disadvantages and complexities of this IPD collaborative approach. A significant hurdle, mentioned in 42% of the articles, is the impossibility of suing internally over disputes and general mistrust, along with complexities in compensation and resource distribution. This reflects the legal and financial intricacies inherent in IPD, where internal conflict resolution mechanisms are constrained [36,114].

**Table 7.** IPD disadvantages.

| IPD Disadvantages                                                                                                                   |                                                                |                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|
| Disadvantages                                                                                                                       | % Percentage of Disadvantages from Ordered List of Publication | Publication List                                       |
| Impossibility of being sued internally over disputes and mistrust, alongside complexities in compensation and resource distribution | 42                                                             | C = [114] E = [34] F = [36] I = [84] L = [14]          |
| Skepticism of the added value of IPD and impossibility of owners' inability to tap into financial reserves from shared risk funds   | 50                                                             | E = [34] F = [36] G = [33] J = [29] K = [27] L = [14]  |
| Difficulty in deciding scope                                                                                                        | 17                                                             | A = [94] H = [12]                                      |
| Difficulty in deciding target cost/Budgeting                                                                                        | 25                                                             | A = [94] D = [45] H = [12]                             |
| Adversarial team relationships and legality issues                                                                                  | 50                                                             | B = [15] C = [114] D = [45] F = [36] K = [27] L = [14] |
| Immature insurance policy for IPD and uneasiness to produce a coordinating document                                                 | 25                                                             | A = [94] J = [29] K = [27]                             |
| Fabricated drawings in place of engineering drawings because of too early interactions                                              | 8                                                              | F = [36]                                               |
| High initial cost of investment in setting up IPD team and difficulty in replacing a member of IPD team                             | 16                                                             | J = [29] L = [14]                                      |
| Inexperience in initiating/developing an IPD team and knowledge level                                                               | 16                                                             | K = [27] L = [14]                                      |

Table 7. Cont.

| IPD Disadvantages                                                                                                                        |                                                                |                                              |
|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------|
| Disadvantages                                                                                                                            | % Percentage of Disadvantages from Ordered List of Publication | Publication List                             |
| Low adoption of IPD due to cultural, financial, and technological barriers                                                               | 33                                                             | E = [34] F = [36] K = [27] L = [14]          |
| High degree of risks amongst teams coming together for IPD and owners responsible for claims, damages, and expenses (liabilities)        | 25                                                             | D = [45] F = [36] L = [14]                   |
| Issues with poor collaboration                                                                                                           | 8                                                              | H = [12]                                     |
| Non-adaptability to IPD environment                                                                                                      | 42                                                             | E = [34] G = [33] J = [29] K = [27] L = [14] |
| Ordered list of publication A = [94] B = [15] C = [114] D = [45] E = [34] F = [36] G = [33] H = [12] I = [84] J = [29] K = [27] L = [14] |                                                                |                                              |

Skepticism of IPD's added value, discussed in 50% of the articles, underscores doubts about its efficiency and the difficulties owners face in accessing shared risk funds [14,27]. Challenges in deciding scope and target cost or budgeting, cited in 17% and 25% of the articles, respectively, point to potential project delays and budget overruns [94,115,116]. Adversarial team relationships and legal issues, addressed in 50% of the articles, signal concerns about team dynamics within IPD.

The immature insurance policies for IPD and the uneasiness in producing a coordinating document, highlighted in 25% of the articles, indicate a lack of established protocols and coordination difficulties within the IPD framework [27,29]. The practice of substituting fabricated drawings for engineering drawings due to premature interactions, though mentioned less frequently (8%), raises quality and timing concerns. The high initial cost of investment required to set up an IPD team and the difficulty of replacing members noted in 17% of the articles, underscore the resource and flexibility challenges in team management [14,29]. Inexperience in creating and developing an IPD Team, also mentioned in 17% of the articles, suggests a steep learning curve and skill disparities among team members.

Low adoption of IPD due to cultural, financial, and technological barriers, discussed in 33% of the articles, reflects broader systemic issues affecting IPD's implementation [34,36]. High degrees of risk and owners' responsibility for claims, damages, and expenses, mentioned in 25% of the articles, indicate a risk-laden environment in IPD projects. Poor collaboration and non-adaptability to the IPD environment, cited in 8% and 42% of the articles, respectively, exacerbate these challenges, often leading to suboptimal outcomes [14,27,29,116]. Collectively, these findings reveal that while IPD is intended to foster collaboration and efficiency in construction projects, it faces legal, financial, managerial, and cultural obstacles that need to be addressed for its effective implementation.

#### 5.1.5. Disadvantages of Design-Build

In a synthesis of 19 (100%) journal articles addressing the complexities in construction engineering and management, particularly within the design-build framework, Table 8 illustrates a range of disadvantages [117]. Notably, the non-competitive selection of teams, a concern in 35% of the articles, indicates a trend where project teams are chosen without prioritizing the best design professionals and general contractors, leading to potential inefficiencies [91,100]. This method's lack of stringent checks, balances, and insurance between designers, general contractors, and owners, discussed in 30% of the articles, signals a gap in oversight and risk management [64,117–120]. Unfair allocation of risk and high startup costs, highlighted in 40% of the articles, pose significant barriers, especially for smaller or less experienced entities [117]. A key issue addressed in 60% of the articles is the limited relationship between the architect/engineer and the clients/owners, reducing the latter's control over the final design and project requirements. This disconnect can lead

to the owner's inability to guarantee the quality of the finished project, as mentioned in 35% of the articles. Further complicating matters is the difficulty in defining the scope of work and managing design alterations during construction, discussed in 35% of the articles, which often leads to project delays and inefficiencies [106,119,121,122].

**Table 8.** Design-build disadvantages.

| DB Disadvantages                                                                                                                                                                                                    |                                                              |                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Disadvantages                                                                                                                                                                                                       | Percentage of Disadvantages from Ordered List of Publication | Publication List                                                                                                                                 |
| Non-competitive selection of team not dependent on best designs of professionals and general contractors                                                                                                            | 35                                                           | B = [121] C = [123] D = [118] E = [119] G = [120] I = [56] J = [106] K = [124] L = [125] M = [126] O = [122] P = [4] Q = [98] R = [117] S = [91] |
| Deficient checks, balances, and insurance among the designer, general contractor, and owner                                                                                                                         | 30                                                           | A = [106] B = [121] C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] L = [125] M = [126] N = [122] U = V            |
| Unfair allocation of risk and high startup cost                                                                                                                                                                     | 40                                                           | R = [117] C = [123] S = [91]                                                                                                                     |
| Architect/Engineer(A/E) not related to clients/owners with no control over the design requirements. A/E has less control or influence over the final design and project requirements                                | 60                                                           | C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] S = [91]                                                           |
| Owner cannot guarantee the quality of the finished project                                                                                                                                                          | 35                                                           | C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] S = [91]                                                           |
| Difficulty in defining SOW, and alterations in the designs after the contract and during construction with decrease in time                                                                                         | 35                                                           | C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] K = [124] M = [126] N = [122]                                      |
| Difficulty in providing track record for design and construction                                                                                                                                                    | 40                                                           | C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] K = [124] N = [122]                                                |
| Discrepancy in quality control and testing intensive of owner's viewpoint                                                                                                                                           | 25                                                           | C = [123] D = [118] E = [119] H = [127] I = [56] J = [106] K = [124] N = [122]                                                                   |
| Delay in design changes, inflexibility, and the absence of a detailed design                                                                                                                                        | 35                                                           | D = [118] E = [119] F = [64] O = [128] R = [117] S = [91]                                                                                        |
| Owner/client needs external support to develop SOW/preliminary design of the project                                                                                                                                | 10                                                           | E = [119] F = [64] L = [125] O = [128] S = [91]                                                                                                  |
| Increased labour costs and tender prices                                                                                                                                                                            | 5                                                            | A = [106] F = [64] G = [120] Q = [98]                                                                                                            |
| Guaranteed maximum price is established with Incomplete designs and work requirement                                                                                                                                | 25                                                           | A = [106] D = [118] G = [120] K = [124] L = [125] M = [126] P = [4] R = [117]                                                                    |
| Responsibility of contractor for omission and changes in design                                                                                                                                                     | 20                                                           | A = [106] B = [121] C = [123] D = [118] S = [91]                                                                                                 |
| Ordered list of publication A = [106] B = [121] C = [123] D = [118] E = [119] F = [64] G = [120] H = [127] I = [56] J = [106] K = [124] L = [125] M = [126] N = [122] O = [128] P = [4] Q = [98] R = [117] S = [91] |                                                              |                                                                                                                                                  |

Discrepancies in quality control from the owner's perspective, cited in 25% of the articles, and delays due to design changes and inflexibility, discussed in 35% of the articles, exacerbate these challenges [124,125]. The need for external support to develop the scope

of work (SOW) and preliminary design, mentioned in 10% of the articles, adds complexity and potential miscommunication between stakeholders [91,100]. Furthermore, this method can lead to increased labor costs, high tender prices, and incomplete designs at the time of establishing a guaranteed maximum price [4,122,126]. Lastly, the contractor's responsibility for omissions and changes in design can lead to significant legal and financial complications, underscoring the inherent disadvantages of the design-build approach in contemporary construction engineering and management.

#### 5.1.6. Disadvantages of Construction Manager at Risk

In a comprehensive review of nine (100%) journal articles on CMAR, Table 9 highlights numerous disadvantages. A significant issue, cited in 78% of the articles, is the unclear definition and relationship of roles and responsibilities between the construction manager (CM) and design professionals [110,129]. Unclear definition often leads to conflicts and inefficiencies. Another major challenge, discussed in 67% of the articles, is the difficulty in enforcing a guaranteed maximum price (GMP), scope of work (SOW), and construction specifications based on incomplete documents [3,130,131]. This often results in disputes and budget overruns, especially when project details are not fully fleshed out early in the process.

**Table 9.** Construction manager at risk disadvantages.

| CMAR Disadvantages                                                                                                    |                                                             |                                                                          |
|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------|
| Disadvantages                                                                                                         | % Percentage of Advantages from Ordered List of Publication | Publication List                                                         |
| Unclear definition and relationship of roles and responsibilities of CM and design professionals                      | 78                                                          | A = [129] B = [110] C = [111] D = [132]<br>G = [130] H = [131] I = [107] |
| Difficult to enforce GMP, SOW, and construction based on incomplete documents                                         | 67                                                          | A = [129] D = [132] E = [133] G = [130]<br>H = [131] I = [107]           |
| Not suitable for small projects or hold trade contractors over GMP tradeoffs and prices                               | 56                                                          | B = [110] C = [111] G = [130] H = [131]<br>I = [107]                     |
| Improper education on CMAR methodology, policies, and regulations                                                     | 56                                                          | E = [133] F = [109] G = [130]<br>H = [131] I = [107]                     |
| Knowledge, conflicts, and communication issues between the designer and the CM                                        | 56                                                          | B = [110] E = [133] F = [109] G = [130]<br>H = [131]                     |
| Shift of responsibilities (including money) from owners/clients to CM                                                 | 44                                                          | A = [129] B = [110] E = [133] I = [107]                                  |
| Additional cost due to design and construction and design defects                                                     | 56                                                          | A = [129] C = [111] D = [132] G = [130]<br>H = [131]                     |
| Inability of CMAR to self-perform during preconstruction                                                              | 11                                                          | C = [111]                                                                |
| Disputes/issues concerning construction quality and the completeness of the design                                    | 22                                                          | A = [129] D = [132]                                                      |
| No information exchange/alignment between the A/E with the CMAR                                                       | 11                                                          | A = [129]                                                                |
| Ordered list of publication A = [129] B = [110] C = [111] D = [132] E = [133] F = [109] G = [130] H = [131] I = [107] |                                                             |                                                                          |

CMAR's unsuitability for small projects and issues with holding trade contractors accountable for GMP tradeoffs cited in 56% of the articles suggest that CMAR may be less

effective for smaller projects and can complicate straightforward tasks [107,111]. Inadequate education in CMAR methodology, policies, and regulations, also mentioned in 56% of the articles, leads to a lack of understanding and improper implementation [8,13]. Knowledge gaps, conflicts, and communication issues between the designer and CM, cited in 56% of the articles, highlight the importance of collaboration, which is often compromised in CMAR projects [110].

The shift of financial and other responsibilities from owners/clients to CM, noted in 44% of the articles, can misalign with owners' expectations [13]. Additional costs due to design and construction defects, mentioned in 56% of the articles, arise from the fast-paced nature of CMAR projects [130,131]. The inability of CMAR to self-perform during preconstruction, although less frequently mentioned (11% times), leads to reliance on subcontractors, affecting project cohesion [111]. Disputes or issues regarding construction quality and the completeness of design, discussed in 22% of the articles, are exacerbated by a lack of information exchange between the A/E and CMAR [132]. These disadvantages collectively suggest that while CMAR offers a structured approach, it faces significant obstacles in role clarity, contractual enforcement, suitability for different project scales, knowledge gaps, financial management, quality assurance, and effective collaboration.

### 5.2. Most Suitable CPD Technique for Sustainable Construction Based on Literature Review

Based on the critical success factors shown in Figure 15, IPD stands out for its emphasis on a collaborative atmosphere and fairness, a trait highlighted in 79% of the articles studied in line with its advantages. This approach fosters a sense of shared purpose and is critical for balancing diverse interests for optimal sustainable outcomes. Early stakeholder involvement, evident in 63% of the studies, is pivotal for ensuring alignment and success in sustainable construction, where decisions significantly impact environmental, social, economic, and technical outcomes. (See Table 10).

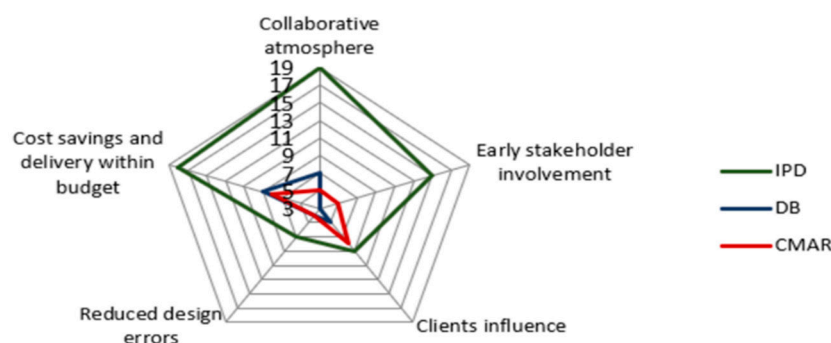


**Figure 15.** Aligning CPD advantages with critical success factors for sustainable construction.

IPD's inherent nature of promoting trust and transparency, as seen in 25% of the related articles, is essential for embracing sustainable practices and technologies. Its focus on reducing schedule time and waste, both mentioned in 42% of the related articles, aligns with the core principles of sustainable construction by minimizing resource use and maximizing efficiency.

Shared cost, risk, reward, and responsibilities (discussed in 75% of the studies on its advantages), along with cooperative agreements (54%) and integrated decision-making and open communication (38%), highlight the importance of joint effort and transparency. In contrast, DB and CMAR, while having major strengths in single-point accountability and potential for cost and time savings, do not inherently prioritize sustainability. DB focuses on speed and efficiency, which might cause it to overlook sustainability aspects. CMAR, though allowing for early stakeholder involvement and offering more control over design, aims for cost savings and budget adherence without explicitly centering on sustainability.

**Table 10.** Critical Success Factors for Sustainable Construction.

| Critical Success Factors for Sustainable Construction                                                                                                                                                 |                                                             |                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------|
| Advantages                                                                                                                                                                                            | Percentage of Advantages from Ordered List of Publication % | Publication List                                                         |
| Collaborative atmosphere                                                                                                                                                                              | 47                                                          | A = [134] C = [135] G = [136] H = [137]<br>K = [138] N = [138] O = [139] |
| Early stakeholder involvement                                                                                                                                                                         | 26                                                          | N = [138] J = [136] I = [136]                                            |
| Reduce design errors                                                                                                                                                                                  | 13                                                          | N = [140] O = [141]                                                      |
| Cost savings and delivery within budget/Client representative                                                                                                                                         | 33                                                          | ABCEF A = [134] B = [142] C = [135]                                      |
| Influence of client                                                                                                                                                                                   | 13                                                          | B = [142] J = [143]                                                      |
| Ordered list of publication A = [134] B = [142] C = [135] D = [144] E = [145] F = [146] G = [136] H = [137] I = [147] J = [143] K = [138] L = [139] M = [148] N = [140] O = [141] P = [149] Q = [147] |                                                             |                                                                          |

However, IPD's advantages align directly with the objectives of sustainable construction. Its foundational principles promote collaboration, trust, and a shared commitment to project goals, including sustainability. IPD's comprehensive approach, encompassing shared responsibilities, cost and risk management, early involvement, and communication, is congruent with sustainable construction's goals of minimizing environmental impact, maximizing resource efficiency, and fostering productivity. Therefore, for projects prioritizing sustainability, IPD is the most suitable CPD technique.

#### 5.2.1. Limitations

This study has several limitations that warrant consideration. Firstly, the scope of this research was confined to a bibliometric analysis and a traditional literature review. While these methods provide valuable insights into trends and general patterns in the literature, they do not offer the in-depth synthesis of data that meta-analyses can provide, which could combine results from multiple studies for a more comprehensive understanding.

Additionally, the research did not extensively explore the critical success factors for sustainable construction. This area is crucial for developing actionable strategies in the field, and its omission means that the findings might not fully address some of the more nuanced aspects of the topic that are vital for practical application.

Lastly, this study was limited to papers available up until 2023. As a result, it does not account for ongoing research and future publications that may provide new insights or contradict the findings presented here.

#### 5.2.2. Recommendations for Future Research

To address these limitations and enhance the robustness of future research in this area, several steps are recommended:

**Expand the Scope of Critical Success Factors:** Subsequent research should focus more extensively on identifying and analyzing the critical success factors for sustainable construction. This could involve detailed case studies, expert interviews, and field surveys to gather qualitative and quantitative data that offer deeper insights into successful practices.

**Ongoing Research Monitoring:** Researchers should continuously monitor the publication of new papers in this field to update their findings and theories. Future studies could set a regular review cycle, such as annually or biannually, to incorporate the latest research and refine understanding over time.

**Broaden Methodological Approaches:** Besides meta-analysis, future research could also employ mixed-method approaches, combining quantitative and qualitative research techniques to provide a more comprehensive view of the subject matter. This could include more extensive use of systematic reviews, content analysis, and thematic analysis to capture a broader range of perspectives and details.

Future research should prioritize incorporating more real-world studies comparing CPD methods with other project delivery methods. Highlighting successful implementations of ECI would offer a fuller evaluation of CPD's practical advantages and limitations. Furthermore, due to the multifaceted and intricate nature of sustainable construction, it is crucial to investigate the applicability and adaptability of CPD in various construction settings.

By addressing these limitations and implementing the recommended steps, future research can significantly contribute to the body of knowledge on sustainable construction and improve the practical application of research findings in this critical area.

## 6. Future Trend

Based on the detailed literature review and bibliometric analysis presented, several research trajectories have emerged for CPD. What follows is a breakdown of current and anticipated trends:

### 6.1. *Enhancing Innovation through Collaborative Project Delivery*

Construction has traditionally been perceived as a sector that is slow to embrace advancements in productivity and innovation, as highlighted by [150]. In this context, trust is increasingly recognized as a key area for future research in construction project delivery methodologies. This focus stems from the understanding that trust among stakeholders—including owners, contractors, designers, and subcontractors—is essential for the effectiveness of CPD methods. The critical role of collaboration and fairness within IPD is particularly emphasized by [151]. Historically, the construction industry has been plagued by adversarial relationships and legal disputes, but nurturing trust can significantly enhance project outcomes, streamline processes, and cut costs. Future research on trust in construction can shed light on practical strategies for establishing and sustaining trust among project participants. This direction is particularly valuable as it delves into the human and relational dimensions of construction management, which are vital for the effective implementation of collaborative project delivery methods.

### 6.2. *Open Communication and Block Chain Technology*

In the construction industry, open communication and blockchain technology are set to revolutionize project management and execution. Open communication ensures a transparent, collaborative environment for all stakeholders, including owners, contractors, and suppliers, which is crucial for reducing misunderstandings and streamlining decision-making, thereby enhancing project efficiency. Blockchain technology, with its decentralized, secure, and transparent nature, offers a transformative approach to data management and transaction processing. It provides an immutable record of transactions, contracts, and updates, significantly improving contract management, payment processing, and supply chain logistics. This integration could reduce disputes, fraud, and administrative costs, leading to a more trustworthy and efficient construction environment. These trends indicate a move towards a more collaborative, transparent, and technologically sophisticated construction industry. The AEC industry's recent research and practice, particularly in creating immutable financial systems, reflect a growing interest in this innovative application [152,153].

### 6.3. *Multi-Party Agreement*

The construction industry is increasingly adopting multi-party agreements (MPAs), which are revolutionizing project delivery. These agreements involve stakeholders like owners, contractors, designers, and subcontractors in a collaborative framework. Multi-party agreements emphasize collective problem-solving, transparency, and mutual accountability. Integrated project delivery exemplifies this approach by focusing on overall project performance rather than individual contributions, as noted by [28,154]. The shift towards MPAs and IPD necessitates a deeper understanding of their collaborative dynamics. Franz, B., and Leicht, R. highlight a shift from competitive bidding to qualification-based selection

aligned with project objectives [66]. This approach opens avenues for academic exploration, especially in integrating technology within IPD and emphasizing collaborative technology. The adoption of MPAs in construction is leading to improved project collaboration, fostering innovation, and continuous improvement. This approach results in fewer delays, cost savings, and higher quality outcomes, making MPAs a key focus for future industry research and practice.

#### 6.4. Utilizing Artificial Intelligence in Decision Support Systems

Several AI techniques have been developed to enable machines to emulate human cognitive functions, such as learning, reasoning, and self-correction [155]. These AI techniques are classified into four primary categories: expert systems, fuzzy logic, machine learning, and optimization algorithms [156]. Specifically, expert systems offer a clear and comprehensible approach to intelligent decision-making by incorporating expert knowledge and reasoning to address complex problems. In practical scenarios, particularly in project management, decision-making often requires human judgment, which can involve a degree of uncertainty regarding the optimal course of action [157]. In addition to the current selection criteria, there is a need for innovations in construction and project management to improve the decision-support models used by owners to choose delivery methods. A promising research direction involves leveraging advanced artificial intelligence techniques to develop intelligent decision models that assist project managers in selecting the most suitable delivery method [158,159]. Consequently, future research on expert systems will likely enhance decision support systems in this context.

### 7. Conclusions

In this research, we extensively explored collaborative project delivery methods, including DB, CMAR, and IPD, using content analysis techniques. Drawing from a Scopus dataset of 1538 journal articles published between 2000 and July 2023, our analysis, powered by the bibliometric tool within R, provides insights into current practices and future trends in these project delivery approaches. Furthermore, an extrapolation of the advantages of the project delivery method was conducted to suggest IPD as the most preferred project delivery method for sustainable construction.

The thematic analysis highlights an evident trend towards collaboration in project delivery. Keywords such as “decision-making”, “project management”, and “integrated project delivery” are prominent. The co-occurrence network presents a holistic view of these intertwined themes, illustrating the interdisciplinary trajectory of research in this domain. Figure 14 visually represents the interrelations between paper titles, keywords, and sources, offering a snapshot of academic contributions in this field. Future projections based on our analysis anticipate advancements in areas like collaboration, trust, open communication, time management, human resource management, risk assessment, and model buildings. Notably, terms like “building information modelling” underscore the growing emphasis on digital tools in sustainable construction, which emphasizes the benefits of real-time collaboration. Our findings cater to a diverse stakeholder group: researchers can discern emerging topics, fostering collective approaches to address challenges in collaborative project deliveries; industry practitioners are equipped with insights into evolving trends, aiding strategic alignment with industry developments; policymakers can leverage this research to create policies bolstering collaboration in construction project delivery.

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