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Review

A Review of Construction Program Delivery Attributes: Bibliometric Analysis of Two Decades

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Abstract: In scholarly construction management, "program" denotes terminologies like "mega-project" and "infrastructure project". Within this framework, the Construction Program Delivery (CPD) system is an indispensable mechanism affecting the entire lifecycle of these complex endeavours. The CPD system harmonises an arrangement of crucial delivery attributes to achieve successful outcomes, rendering the elucidation of these attributes a scholarly imperative. Numerous studies have identified multiple attributes that impact delivery strategies in the construction industry. However, only a limited number of studies have focused explicitly on the CPD attributes. Hence, the study aims to explore the main drivers of CPD methods based on a systematic review, including a bibliometric analysis over the current century in existing literature. It also addresses current research trends and gaps in the delivery context concerning mega projects. The two major-step research methodology involves a bibliometric assessment and determining key delivery attributes. A bibliometric analysis was conducted using 639 journal articles focused on CPD. Ultimately, the analysis of the findings and existing knowledge of the CPD literature have revealed that researchers, as well as construction agencies, have emphasised regulatory and technical aspects embedded within a socio-economic context conveying normative and cultural attributes when addressing CPD. These triple aspects of the delivery strategy have been considered by scholars simultaneously for a successful construction program.

Keywords: delivery; construction; program; complexity; attribute; causal; uncertainty; interrelation; bibliometric

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1. Introduction

Within the construction industry, several terms have been used to describe programs, including "mega-project", "mega-construction project", "infrastructure project", "large-scale project", and "complex project" [1,2]. Construction programs are often characterised by a high investment (more than one billion dollars) [3–5], a lengthy timeline (over two years), and many social consequences [6], which are either partially or fully invested or commissioned by governments [7]. They are also defined by the difficulty of implementing the project, integral management necessity, and the consideration of operations throughout the design and construction phase since they are enormous in field size and include different aspects of complexity [8]. Some terminologies, such as mega-project, infrastructure project, large-scale project, or complex project, have been used in the construction industry to illustrate programs in practice [1,2]. A common characteristic of construction programs is their immense complexity, both in human and technical terms, as well as a long history of poor delivery. Poor delivery includes exceeding schedules and budgets, providing low-quality results, and delivering inadequate value to customers [9,10]. Over 65% of construction programs are reported to have failed during their completion worldwide [11,12]. They are associated with substantial uncertainty and complexity, lead to soaring delivery risks, and exceed budgets by over 50% expected [13].

It is common worldwide for construction programs to fail in order to meet quality, time, or budget requirements, which generally leads to output dissatisfaction and extensive

time and cost overruns [14]. Four studies compiled by [4] reported an increase in the original estimated cost of transportation infrastructure projects of up to 500 per cent. Overemphasis on iron triangle objectives (time, budget, and scope) and the challenges of conventional project management theories have been identified as potential contributors to construction project programs' failures [14]. Project management does not involve an integrated approach that can streamline the successful delivery of projects [15,16] while disregarding value-generation procedures [17].

A mega construction project's inherent characteristics influence the aptness of a particular delivery approach [18]. Several research studies emphasised various aspects of CPD, like selecting the most appropriate delivery strategy by adopting qualitative and quantitative models [19–28] or broadening managerial views to concurrently enable firms to employ their skills and knowledge effectively and discover alternatives for flexible reciprocity [2,5,29–33], however, a systematic review of the existing body of knowledge is absent, especially in the case of clarifying a clear-cut set of delivery attributes integrated into a resilient framework for construction programs. Such a systematic study would identify the current literature nuclei and gaps and indicate future research directions and trends.

The review examines current trends in recognising the primary factors and aspects involved in CPDs. Covering an extensive timeframe from 2000 to the end of January 2023, this investigation further enables construction agencies and owners to undertake possible amendments within a nuanced and balanced delivery framework. Following the introductory framework, the next section elucidates the critical significance of the research, accentuating the scholarly void related to pertinent CPD attributes. This theoretical cornerstone sets the stage for the upcoming methodology section, which justifies the utilisation of bibliometric analysis as the investigative tool of choice. In the analysis section, a gamut of critical data metrics—such as publication rates and citation frequencies—are meticulously evaluated. Extracted insights inform the subsequent identification and enumeration of essential attributes relevant to CPD, subjecting them to in-depth scrutiny in the discussion section. The scholarly inquiry reaches its zenith in a concluding section, encapsulating seminal findings, inherent research limitations, and a strategic direction for future academic pursuits.

2. Research Significance and Methodologies

The delivery approach enormously affects the schedule, cost, quality, and scope management [19,34,35]. Construction project programs are construction agencies' tactical apparatuses linked to strategy, vision, and values. An accomplished project program will culminate in achieving the business objectives of a construction agency [36,37]. Thus, the program delivery framework for providing benefits must be adaptively optimised [38], considering not only the iron triangle goals in project management but also the agencies' values and visions. Construction agencies also tend to decompose a program into integrated, clearly defined individual components to cope with the immense inherent complexity and uncertainty [33,39]. However, deploying a conventional delivery framework may result in neglecting some interrelated traits, causing a gap between project and program delivery [29]. A systematic review is also seldom conducted, which may assist practitioners in better understanding existing trends, limitations, impediments, and future opportunities regarding construction program delivery. The review outcomes will help recognise current delivery attributes as well as identify gaps in the development of mega-construction delivery strategies. The study outcomes will also allow various construction agencies to understand the factors to consider when selecting or customising a delivery strategy.

There are limitless delivery attributes and qualities bound in different frameworks utilised either to develop a delivery framework or model to select a strategy. Researchers have attempted to compile a comprehensive list of factors and frames influencing the project delivery phase; nonetheless, these structures complement each other despite being quite different regarding different visions, and no research has gained general recognition [40,41]. Furthermore, the key parameter that leads to the inclusion of unimportant attributes or the omission of critical qualities is the lack of a framework capable of contex-

tualisation analysis of the governing mechanism [42–44]. Therefore, this study aimed to explore delivery attributes regarding CPD phase. To achieve this, a structured review was conducted to critically assess the current understanding of the research topic, including the bibliometric assessment to assist in uncovering recent trends and research gaps by providing a comparative analysis of published papers [45].

A structured keyword search was conducted in two databases, Scopus and Web of Science, in order to recognise delivery papers in construction program environments. WoS and Scopus were chosen as the most comprehensive and easily adaptable databases for bibliometric assessment software [46,47]. Keyword combinations were searched for as follows: "Deliver*", "Complex", "Construction", "Program*", "Project", "Procure", "Large scale", "Mega", and "Infrastructure", considering database search adjustments like the "deliver" AND "construction program*" phrase in the Scopus database. The selection process was limited to papers published in peer-reviewed journals in English from 2000 to the present, as shown in Figure 1. Bibliometrix was the software program utilised for the bibliometric assessment, and "R" studio was programmed earlier to remove duplicate papers from the dataset [48]. Utilising bibliometrics software enables researchers to evaluate and quantify the impact and influence of scholarly research by analyses of the scientific literature, citation patterns, and other bibliographic data. The software is beneficial to identifying key papers and authors, evaluating research impact, monitoring research trends, benchmarking research performance, improving grant proposals, and supporting academic publishing [49,50].

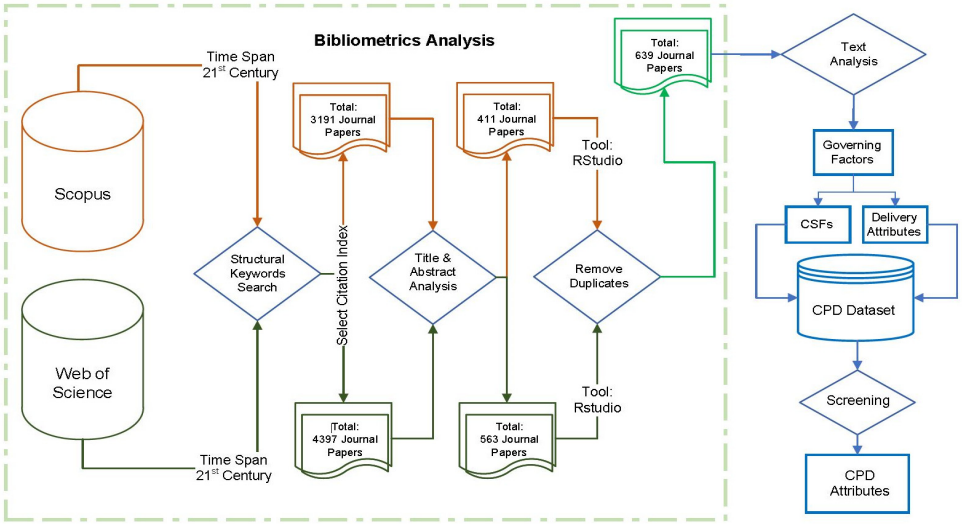

Figure 1. The research methodology process.

Figure 1 illustrates the research methodology process, which ultimately resulted in the realisation of CPD attributes. Regarding conducting the structural keyword search, the papers were subjected to the three filtering processes used by [51], including analysis of the title, abstract, and text,. Six hundred and thirty-nine (639) papers were identified related to the theme based on the first three primary steps. These peer-reviewed journal articles were examined through bibliometric analysis. Section four reviewed the most dominant delivery attributes regarding mega-construction projects. A detailed review of the CPD attributes was undertaken, including delivery Critical Success Factors (CSFs) and selected attributes for CPD method selection.

The rationale for the distinct yet interrelated examinations of CSFs and delivery method selection attributes within the systematic review pertains to their cumulative impact on CPD performance. CSFs serve as the strategic cornerstone, delineating essential criteria requisite for the attainment of project objectives. Conversely, delivery attributes function as the operational mechanisms critical for materialising these overarching goals.

The CSFs bifurcate into controllable and inherent categories. The former directly correlates with delivery selection attributes, encompassing organisational levers that clients can manipulate to bolster operational efficiency—such as structural design and risk allocation parameters [52,53]. Conversely, inherent factors are immutable, exogenous variables necessitating adaptive delivery strategy frameworks [54,55]. As a result, the functional utility of the delivery method is instrumental in realising the strategic goals outlined by CSFs, underlining their symbiotic relationship. Moreover, the intertwined influence of CSFs and delivery system extends across a continuum of performance metrics, from intermediary "soft issues" to ultimate "hard outcomes" [56,57]. This intricate interplay elucidates the complex factors shaping CPD performance, thus advocating for a holistic, methodologically integrated approach for scholarly examination. This integrative focus is corroborated by current literature and offers a nuanced lens for dissecting the complexities inherent to CPD performance [53,58,59].

Moreover, in order to conduct a detailed review of CPD attributes, 229 articles were reviewed. However, just 40 were explicitly associated with CPD. A dataset was constructed, which required screening. In order to screen attributes, repetitive attributes were removed, and the rest was categorised based on relevancy. Finally, an analysis of the categories and the relative importance of each (expressed as the number of citations of criteria in the category/the total number of citations) is presented in Table 1. The measurement was created to ensure that all delivery attributes were evaluated on the same criteria and that the relative importance of each category was evident.

Table 1. Main information from the bibliometric analysis.

Description	Results
Main Information about the Data	
Timespan	2000:2023
Sources (Journals, Books, etc.)	180
Documents	639
Annual Growth Rate %	−2.97
Document Average Age	7.53
Average citations per doc	24.41
References	27,014
Document Contents	
Keywords Plus (ID)	2117
Author's Keywords (DE)	1625
Authors	
Authors	1356
Authors of single-authored docs	61
Authors Collaboration	
Single-authored docs	66
Co-Authors per Doc	2.97
International co-authorships %	12.68
Collaboration Index	2.25
Document Types	
Article	624
Article; early access	15

3. Bibliometric Findings

3.1. Findings

Table 1 summarises the main findings of the bibliometric analysis. The research included 639 journal articles derived from 180 journals written by 1356 authors. As indicated by the "Co-authors per document" parameter (2.97), three co-authors are typically involved

in creating one article. Sixty-one single authors have written sixty-six articles in terms of the CPD environment. The "collaboration index" is an indicative phrase that estimates the number of authors in a multi-authored article relative to the total number of multi-authored articles that have been published. As a result, it is possible to gain an understanding of the level of collaboration for each published article [60].

Moreover, it may be interpreted that the "Document Average Age" of 7.53 years in the research timespan reflects new research being published frequently and that a substantial amount of literature has been published in recent years concerning the CPD. This indicates that the field is attentive and that new insights are being added to the existing body of knowledge. Therefore, it is crucial to stay up to date with the most current research in the field in order to benefit from the latest developments. In the context of CPD research, a citation rate of 24.41 may be considered adequate or even excellent, especially when the analysis focuses on recent works. There is a good chance that the research will continue to be cited since scholars consider it high quality and relevant.

The bibliometric analysis reveals a pronounced exponential escalation in scholarly publications between the years 2016 and 2017. The bibliometric data reveal a discernible uptick in publication frequency commencing from the year 2005. Between 2017 and 2018, there was a significant fall in the number of scientific publications related to the CPD context, followed by a surge in 2019. These may be associated with several factors, including global economic circumstances, research satiety and novelty, CPD's new prioritisations, and interests in some aspects such as sustainability, regulations, and policies governing construction agencies and financiers, technological advancement, research funding policies changes, and a change in the number of researchers engaged in CPD [61].

On the contrary, the analysis indicates that the average annual citation rate for articles exhibits irregular growth patterns. Regarding the fluctuations in the period, one or more published papers reached the top in 2005 and 2018, for instance. A change in CPD research focus and perspectives, the emergence of new methodologies and evaluating models, changes in publication practices, an increase in visibility and accessibility, citation author's reputation, journal and country diversity in terms of citations, and topics' diversity covered by the journal [62] could lead the number of article citations per year to fluctuate between 2000 and 2022. These possible changes could lead to a more global outlook on CPD research, potentially resulting in a broader impact on the field. This, in turn, could drive more collaboration and interdisciplinary work between researchers, allowing for a more holistic approach to tackling research questions.

The bibliometric analysis reveals that, within the research timespan, three major publications emerge as the most relevant sources, and there is a discernible dynamic in cumulative occurrences. These three governing publications are the "*International Journal of Project Management*", "*Journal of Management in Engineering*", and "*Journal of Construction Engineering and Management*". Several factors may contribute to their popularity among scholars, including their academic reputation, a broad range of topics related to CPD covering, possession of a well-known editorial board, and high citation impact.

The analysis also indicates a marked exponential increase in CPD research commencing in 2010. The high number of publications in these journals as well as the meteoric rise highlight project management scholars' focus on CPD performance. The following are possible explanations: First, the complexity and uncertainty of the CPD are increasing. These have led to an increasing need for research to consider how to manage them effectively. Secondly, infrastructure development has gained increased attention worldwide, with governments investing heavily in large-scale projects like airports, highways, and power plants. Therefore, research is needed to ponder how to succeed with CPDs. Finally, fresh approaches and methodologies have emerged in project management theories and practices over the past decade. Consequently, scholars may focus on CPD performance to examine the application of these new approaches due to the advancements.

Three-plot Sankey graphs are presented in Figures 2 and 3 to demonstrate the pivotal relationship between the research focuses across the analysed publications on CPD

during the recent century. A line's thickness indicates the degree of relationship between two variables [60]. Figure 2 depicts the relationship between "top authors", "keywords", and "publication source". It should be noted that "top authors" refers to the first author in the publication mentioned in the figure. The analysis indicates that the "*Journal of Construction Engineering and Management*", "*International Journal of Project Management*", "*Construction Management and Economics*", and "*Journal of Management Engineering*" were targeted by prolific authors to publish articles related to CPD research. These articles scrutinised different aspects of the research topic, such as Public–Private Partnership (PPP) performance as a CPD strategy, infrastructure planning, and risk assessment. As shown, "project management" was the most dominant keyword among top authors and journals. It may indicate that delivering construction programs requires effective project management due to a high failure rate. It may also show that urbanisation, population growth, and technological advancements have contributed to the interest in CPD research.

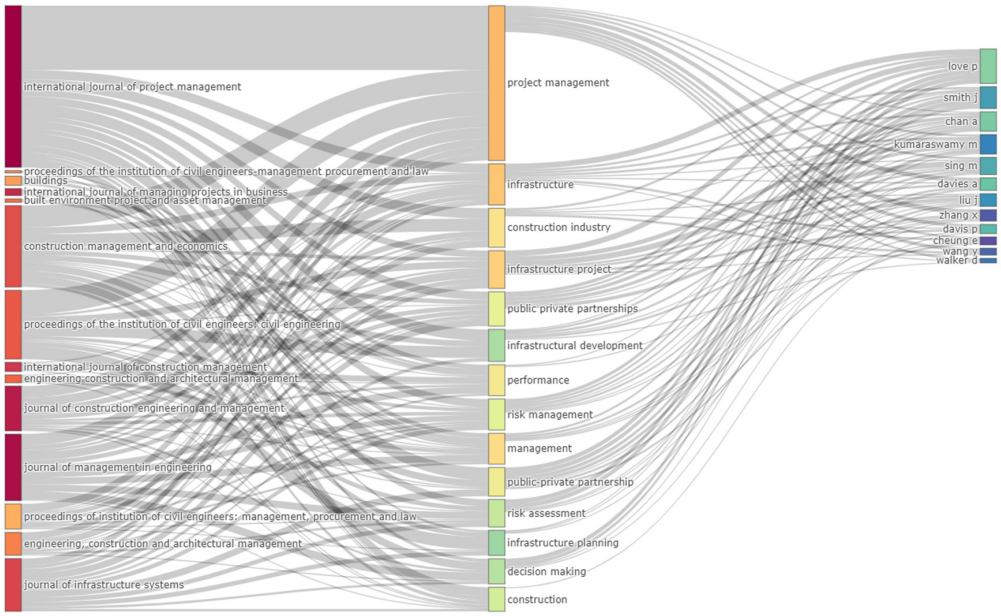

Figure 2. Three-plot graphs between top authors vs. keywords vs. publications source.

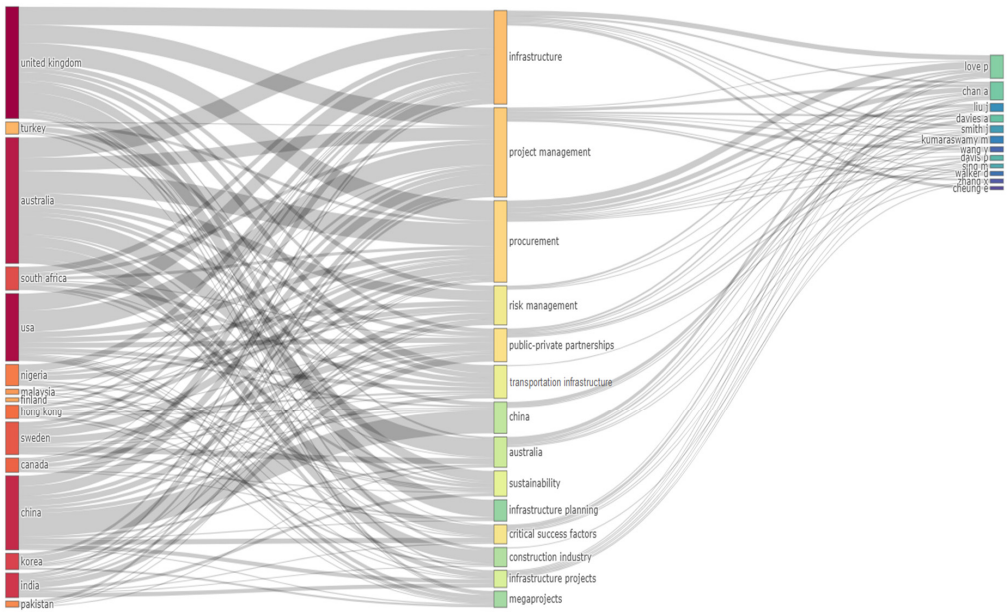

Figure 3. Three-plot graphs between top authors vs. research focus vs. country.

The interrelation between "top authors", "research focus", and "country" reveals the research priorities of works published in nations where CPD is given high priority. Australia, the United Kingdom, China, and the USA lead in generating articles regarding infrastructure project environment. This may be due to running different types and numbers of concurrent mega-projects in those countries, which could considerably impact the economic environment. Furthermore, Australia and the UK lead generation of articles on infrastructure projects' procurement. Regarding delivery strategy selection for mega-projects, it seems PPP is one the most popular approaches for CPD.

Both Figures 2 and 3 show that risk management is a major area of research for CPDs. Technology, economics, aesthetics, and political factors all could create risks regarding CPDs [63]. Developing methods for optimising information processes and providing reliable inputs for estimating the economic, technical, and financial impacts of risk-mitigating actions is possible through studying risk management and assessment by scholars [63]. Risk management as a trend in the CPD research area can be derived from demanding proactive risk management strategies rather than reactive approaches in the industry, enhancing risk management tools and methods and increasing recognition of risk management's role in reducing the probability of CPDs failures.

Moreover, based on Figure 3, sustainability was a key research focus in leading countries regarding CPD research. However, it seems that top authors have not been interrogated on the subject. This might be due to the following reasons such as political factors. There may have been no government regulations in place to encourage sustainable practices in the industry, which can result in no incentive for academics. Secondly, to make informed statements about sustainability in CPDs, the authors may not have had access to sufficient data. Identifying and quantifying the environmental benefits of CPDs can be difficult due to long-term and uncertain impacts. Finally, an in-depth understanding of sustainability requires a combination of environmental, social, and economic perspectives. Collaborative efforts are required among authors with varying levels of expertise. Thus, sustainability in CPDs may have been beyond the expertise of certain authors.

It is likely that fresh academics have interrogated sustainability subject matter in light of existing concerns among influential stakeholders, including financiers and scholarship recipients, despite the fact that top authors have not significantly contributed to the topic.

The bibliometric analysis further reveals that academic contributions to the field of CPD are chiefly emanating from four dominant nations: the United States, Australia, China, and the United Kingdom. This disproportionate representation underscores the global influence of these nations in shaping the CPD research landscape. Moreover, the analysis brings to light specific bilateral academic collaborations of notable significance. These include collaborations between Australia and China, Australia and the United Kingdom, China and the United States, as well as the United Kingdom and Nigeria. The impetus for such robust collaborative endeavours likely derives from a confluence of factors, encompassing economic interdependencies, geopolitical alignments, technical proficiencies, and cultural–cognitive affinities between these nations.

Figure 4 delineates the recent research trend topics in the domain of CPD contextualisation. It is discernible from the graph that, while construction program management has indeed been a subject of investigation in the construction industry, it has not been as frequently addressed by scholars as one might expect. In the recent past, however, researchers have demonstrated a growing interest in exploring specific areas within the domain, particularly those related to Building Information Modelling (BIM) stakeholder management, contract management, and the application of institutional theory framework in CPD, as pointed out by the arrows in the figure. This focus on these aspects is likely driven by the industry's need to improve outcomes, minimise conflicts and disputes, and nurture better collaboration among stakeholders involved in CPDs. Intriguingly, the research trends suggest a cyclical pattern wherein most topics tend to decline in popularity after about five to six years. An exception to this observation is the Design–Build strategy, which has managed to maintain its relevance for more than a decade. The early 21st century

saw Design–Build as a dominant procurement paradigm in academic investigations. However, the paradigm has progressively shifted towards more contemporary procurement approaches, such as public–private partnerships. Concluding this analysis, while "cost performance", for instance, has been emphasised in the data, new trends are indeed beginning to gather momentum. Despite their relative novelty, these emerging topics highlight an industry-wide shift. This shift is oriented not only towards guaranteeing robust responses to unexpected circumstances, but also towards enhancing the management of the delivery phase of construction programs.

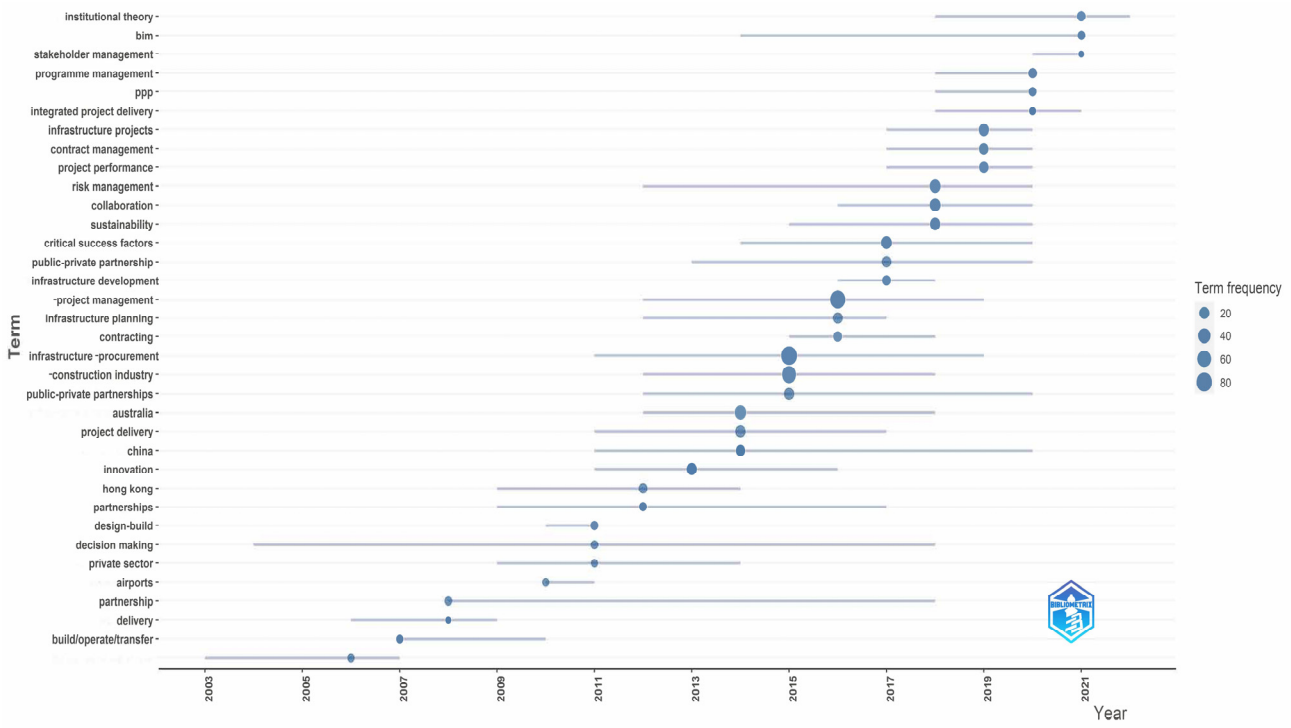

Figure 4. Trend topics in research lifespan.

3.2. Bibliometric Synopsis

Key findings and observations from the bibliometric assessment are summarised below:

- Three leading journals are the *International Journal of Project Management*, *Journal of Management in Engineering*, and *Journal of Construction Engineering and Management*, and four dominant countries, Australia, the USA, the UK, and China, have published research on the context of CPDs.
- Even though there are extensive collaborations among countries in CPD research, the Australia–China, Australia–UK, China–USA, and UK–Nigeria relationships are considered to be more meaningful.
- Scholars have focused primarily on management paradigms such as using institutional framework, risk assessment, procurement, CSFs, and performance factors concerning the CPD.
- Some delivery strategies like Building–Operate–Transfer and DB are gradually supplanted chronologically in the research context by other delivery frameworks such as PPP and Integrated Project Delivery (IPD).

Perhaps, this happened since newer delivery frameworks are faster in completion for construction programs and have better risk management strategies in place [64]. Additionally, BOT and DB do not allow the same degree of collaboration and coordination between stakeholders [65].

- A recent trend in research has been to look at how social values such as collaboration and corporate responsibility affect the delivery of infrastructure projects.

This is in addition to looking at how regulatory delivery factors like cost and design management approach affect CDP. This shift in focus may be driven by the need to improve end results, public interests, and concerns, and CPD risk mitigation in addition to conventional delivery attributes.

- Even though program management has now found a trend in CPD research, conventional project management is still the current research nucleus.

Considering economic pressures, project management limitations and maturity, along with the dynamic nature of construction industry clients' preferences, have prompted program management adoption and implementation in the construction industry as a de facto means of coordinating, aligning, and managing a portfolio of construction project programs to deliver benefits that would be unattainable if they were each undertaken independently [66]. Program management offers many benefits, but its awareness and understanding in the construction industry remain unclear due to a lack of clarity and inconsistency surrounding its definition. In contrast to disciplines such as project management, which have matured over time, a dearth of literature accurately describes the nature and practice of program management in the construction industry [32].

- As evidenced by a triadic interrelation of preeminent authors, focal domains, and national affiliations shown in Figure 3, transportation emerges as the predominant sector of scholarly inquiry in CPD, eclipsing other infrastructure categories like ports and Olympic complexes.

The reason could be that transportation construction programs involve managing multiple projects to achieve a shared goal and coordinating between different stakeholders, making them a more suitable topic for studying delivery effectiveness [67]. The transport infrastructure also has a long-term and substantial impact on the economy. Therefore, it is advantageous for policymakers and investors to fund academics to understand how these programs are delivered successfully.

- Regarding delivery system selection methods in research, multi-attribute decision-making models, including fuzzy logic approaches, are preferable to other methods, such as guidance and knowledge/experience based [21].

This may be because decision-making models allow for the consideration of multiple criteria when selecting delivery strategies, thereby providing a more comprehensive evaluation of the options. Additionally, fuzzy logic approaches are well suited to address the uncertainties and complexities inherent in PDS selection processes [68,69].

According to the results of the bibliometric analysis, readers can identify key research themes and trends in the CPD context, as well as identify influential journals, countries, and research focus areas. This analysis uses citation metrics to measure the impact of research output and identify the most cited authors, journals, and nations in the field. It also examines citation patterns to determine which topic's subsets are the most dominant and which areas are the most active in terms of research output.

According to the systematic review, the majority of resources published in related journals have been devoted to the different aspects of CPD. However, a systematic review has rarely been conducted focusing specifically on the factors contributing to CPD strategy selection. This lack of research is likely because this process requires focusing on a multidisciplinary approach. The following section reviews the significant delivery attributes that govern CPD strategy selection. In light of antecedent justifications, observations corroborate those two primary contexts merit focused scrutiny in the domain of CPD strategy selection, precisely, delivery system selection attributes and CSFs. Reviewing these factors assists in unveiling the gap in the literature concerning the selection of the CPD method.

4. Construction Program Delivery Attributes

4.1. Contextual Framework

Construction agencies use delivery strategies to determine stakeholder roles, divide authority and responsibilities, and allocate profit and risk appropriately. They also help to organise and motivate stakeholders to meet the client's values and objectives [21,70]. Selecting an appropriate delivery method is pivotal to clients because they can provide a single point of responsibility for the completion of the project, allowing the client to focus on their core business and not become distracted by daily project management. This can benefit all parties involved, not just the client [71]. Thus, choosing an appropriate delivery approach is crucial to project success, and scholars across the globe have studied the delivery selection methods [72] from different perspectives. Although numerous studies have examined delivery strategy selection, many related issues remain unresolved in practice [42].

An effective delivery selection methodology relies on identifying governing attributes [40,73,74]. A comprehensive understanding of these attributes assists in facilitating industry and academia better comprehend how and why certain delivery methods are chosen in different contexts [75]. Moreover, in managing construction projects and programs, poor delivery method selection is likely to result from limited information, little and biased prior experience, and poorly identified factors [40,74,76]. Although several well-researched and sophisticated MCDMs are available in the literature, few scholars have fully employed them because of the challenges associated with comprehending the techniques and choosing the model parameters [41]. Having an appropriately identified list of delivery method selection attributes is beneficial to practitioners in practice [77,78].

As noted, 40 papers were found concerning CPD attributes and CSFs. Out of these studies, eight articles were associated with construction program delivery CSFs, and the others reported delivery attributes concerning different delivery contexts, like selecting a strategy for a specific case study. USA, China, Australia, and the UK had the most scientific production regarding the delivery phase in the construction industry. Among different types of construction programs, including infrastructure, extraction, production, and military hardware [79], mega-transport infrastructure projects were the primary construction program type that scholars reviewed.

4.2. Analysis

Based on the reviews of journal articles published within the current century, Table 2 provides an overview of CPD attributes. In reviewing governing factors and CSFs, the most significant attributes pertinent to CPD were obtained. In order to do this, two primary steps were taken. Firstly, uncertain factors should be primarily transformed into determinants. This is because, when analysing CSF, all the variables have been fixed and have taken on their final form. Therefore, the analyst can make more accurate assessments of the chosen delivery system. On the other hand, when selecting a delivery system, all the variables are still in flux, which leaves a lot of uncertainty in the selection process. In other words, all certain CSFs and competent delivery attributes could not be addressed at the beginning of any project; therefore, they must be elucidated and acknowledged in the closing phase. For example, the contractor's design maturity organisation is unavoidable, but it is debatable at the stage of selecting the delivery strategy. This is because the contractor is required to demonstrate their capability of designing and constructing the system to meet the performance requirements of the owners, which can only be assessed when the detailed design is known. At the delivery strategy selection stage, construction agencies only have a high-level overview of the system and can only select a delivery strategy based on their understanding of the requirements and past knowledge. It is, therefore, essential to transform the contractor's design organisation maturity factor into its determinants, such as potential contractors' ability, competitiveness among design market resources, and contractor's design experience. Another aspect that should be considered is eliminating irrelevant CSFs, such as communication devices. These factors are neither capable enough to impact the other delivery attributes nor perform anomalously under different delivery strategies [42].

Table 2. CPD attributes.

Governance and Administration 7.04%			**Design Management Approach 10.03%**		
Organisation type and size	[3,24,40,80–84]	1.20%	Agency control over design	[3,40,42,81,83,85–88]	1.35%
Program organisation maturity	[3,42,56–58,82,84,87,89–93]	1.95%	Level of design completion, detailing, quality, and documentation	[42,57,80,83,86,87,91–97]	1.95%
Top management or agency support	[3,42,57,58,81,84,90–92]	1.35%	Flexibility regarding design	[3,24,81,85,86,91,94,95,97–101]	1.95%
Organisational responsibilities assigned to the right-sized capable team	[80,82,84,90,92]	0.75%	Teams' capability	[3,42,83,91]	0.60%
			Construction program innovation features	[39,40,42,57,85,87,92,99,101]	1.35%
PM approach	[42,58,84,87,90,92,93,96,98]	1.35%	Sustainability	[80,85,89,102]	0.60%
Transparency	[84,92,96]	0.45%	Constructability	[40,56,81,82,85,96,97,99,101,103,104]	1.65%
Risk Allocation 11.53%					
			Early contractor engagement in the design Phase	[3,56,89,99]	0.60%
Schedule risks	[3,24,39,80,85–89,93,96,97,99,101,103–106]	2.69%			
Technical risk	[3,24,40,42,80,81,83,85,89,92–94,96,100,101,103–105]	2.69%	**Finance Approach 5.24%**		
Organisational risk	[24,56,80,85,89,90,92,96,104]	1.35%	Source of funding capacity	[3,24,39,40,42,57,81,82,85,87,88,90,96,99,103]	2.25%
Financial/Cost risks	[3,24,39,80,85–89,93,96,99,101,103–106]	2.40%	Funding cycle	[3,42,57,82,88,95,96]	1.05%
Management risk	[3,24,42,56,80,85,90,92–94,96,97,103–105,107]	2.40%	Stakeholder partnership/shares and credibility	[42,57,87,89,96]	0.75%
			Cash flow Status	[3,24,57,82,85,89,95,96]	1.20%
Cost and time Determinants 11.23%			**Legislative Procedure 5.39%**		
Delivery speed	[3,73,85,86,88,93,94,98,99,101]	1.50%	Dispute Resolution/jurisdictional complexities	[56,81,89,94,103]	0.75%
Contract type	[3,82,84,86,89,94,95,98,99,101,107]	1.65%	Engagement of the government	[81,86,90,94]	0.60%
Payment time flexibility	[3,80,82]	0.45%			
Value for money	[3,40,80,82,87]	0.75%			
Tender and contract award approach	[3,57,85–89,98]	1.20%	Legislative Prerequisite/Regulatory and statutory requirements	[42,80,85,86,90,94,97,103,108]	1.35%
Completion of estimated (original) budget and schedule	[24,40,42,57,80,81,83,86–88,90,92,98,99,101,103,105,106]	2.69%	Regulatory Feasibility	[3,40,80,91,94,97,101,108]	1.20%
Predictability	[3,24,80–82,86,87,96–99,101,103,105–107]	2.54%	Contracting law clarity	[3,42,56,86,89,91,93–96]	1.50%
Change orders frequency	[88,96,101]	0.45%			

Table 2. *Cont.*

Governance and Administration 7.04%			**Design Management Approach 10.03%**		
Scope Definability 7.63%			**Stakeholder Influences/Intervention 5.69%**		
Main drivers	[3,24,39,40,56,57,81,82,90,91,100,101,107]	1.95%	Political stability	[40,74,75,85,86,89,92,93,98,105]	1.50%
Goals	[24,39,42,56,85,90,92,93,98,107]	1.50%	Consensus on rules of governance	[39,56,57,83,84,86–88,90,91,93,96]	1.80%
Lifecycle expected span	[39,85,90,96,101]	0.75%			
Certain outcomes	[39,42,56,57,81,82,85,87,89,90,93,98,100, 101,107]	2.25%	Dispute resolution and frequency	[80,84,86,87,90,91,98,100,101,108]	1.50%
Scope creep	[3,39,42,68,91,94,96,100]	1.20%			
			Third-party agreement	[3,40,87,93,94,97]	0.90%
Technical Clarity 5.24%			**Local and environmental preferences 4.94%**		
Resource technical competency	[42,57,83,85,89,92,93,96–98,103,107]	1.80%	Local condition of the program site, size and type	[1,39,40,42,74,75,77,79–81,86,89,91,95–98,100,104,105]	2.99%
Contractor capability	[3,42,57,80,82,85,91,97,101,108]	1.50%	Environmental Impact	[40,81,85,88,89,92–94,96,97,101,104,108]	1.95%
In-house technical capability	[3,40,42,80,82,83,85,86,88,96,99,101,108]	1.95%			
Economic influences 1.50%			**Logistics 1.20%**		
Stability/Growth	[39,91,95,99,103]	0.75%	Logistics planning approach	[39,87,109,110]	0.60%
Inflation rate	[42,89,93,96,99]	0.75%			
Market Status 4.19%			Proximity to resources	[80]	0.15%
Market stability/availability	[40,80,81,85,87,93,99,108]	1.20%	logistics challenges	[80,97,108]	0.45%
Market competitiveness	[3,40,80,81,84,85,87,93,99,101,103,108]	1.80%	**Institutional cognitive load 2.54%**		
Certain GC/subcontractor availability and credibility	[40,42,80,81,91,97,99,101,107]	1.20%	Status que bias	[83,108]	0.30%
			Institutional wisdom	[86,91,103]	0.45%
Resource workload 3.89%			Cultural environment	[3,40,42,57,80,81,84,87,91,92,95,108]	1.80%
Human resource allocation	[39,40,56,57,80–82,84,86,89–93,101,107]	2.40%	**Agency history 4.04%**		
Other resources allocation	[39,57,80,81,84,90–93,107]	1.50%	Familiarity and experience	[3,24,39,40,57,83,86,87,90,91,97,99, 103]	1.95%
Quality management 5.09%			knowledge retention	[39,57,83,87,90,92,96]	1.05%
			Risk toleration	[3,40,42,83,85,101,103]	1.05%
Quality performance	[3,24,42,73,80–82,85,91,94,98,101,103–105]	2.25%	**Teamworking 3.59%**		
Consensus on quality standards	[56,80,85]	0.45%	Certain incentives and penalties	[91,95,96]	45%
Quality control and safety	[42,80,81,86,87,91,92,94,95,98]	1.50%	Credibility in commitments	[56,83,91,107]	0.60%
Quality assurance	[3,42,56,80,91,94]	0.90%	Teams' trust, cooperation and coordination	[40,42,56,81,84,86–88,91,92,95,96]	1.80%
			Program organisation responsibility	[80,82,88,95,96]	0.75%

As previously mentioned, the relative importance of each category pertaining to delivery attributes is determined based on the frequency of citations. The method emphasises objectivity, reducing bias by relying on empirical citation frequencies, reflects consensus within the academic field, and is adaptable, evolving alongside new research. By monitoring citation trends, it facilitates identification of shifts within the field. As a data-driven approach, it relies on empirical evidence rather than subjective judgments.

Table 2 and Figure 5 present the selection criteria derived from the selected publications, including 18 categories of attributes and 74 sub-categories, and the relative importance of each category. The categories have also been broken down based on attribute pertinence. The heterogeneity among the collected attributes was too broad due to different research perspectives and goals. Therefore, a single-term category was created based on items with similar understandings during the screening process [54,81].

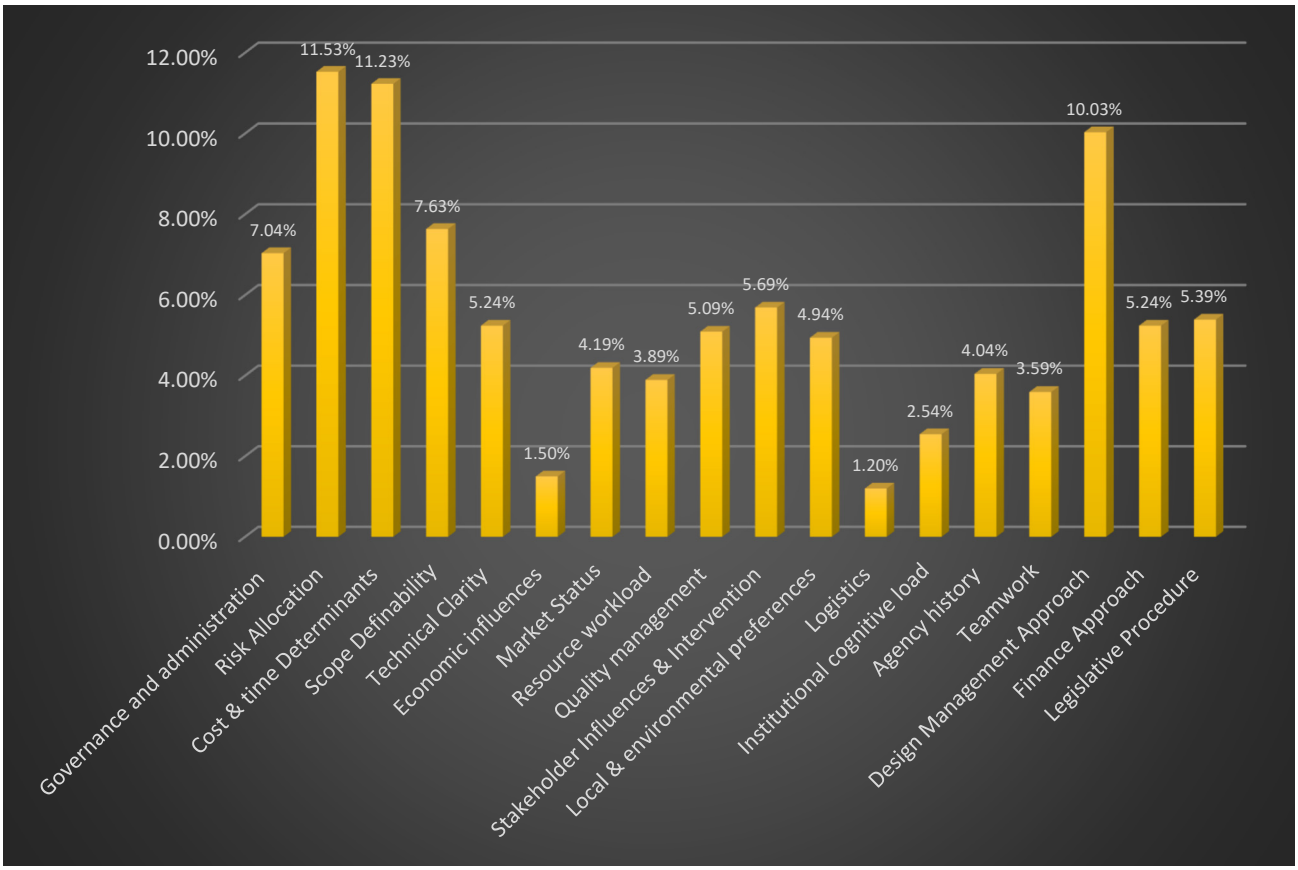

Figure 5. CPD attribute citation leverage.

The identified attributes influencing CPD can be stratified into three principal categories: regulatory, normative, and cultural–cognitive. These categories are not isolated phenomena but function profoundly interconnectedly, often manifesting symbiotic relationships. Specifically, the regulatory attributes fundamental to the governance structures and contractual frameworks of CPD do not operate in isolation; rather, they are inherently situated within a broader socio-economic context. This contextual milieu is not merely a passive backdrop but is intricately shaped by normative and cultural–cognitive attributes, which in turn exert a modulatory influence on the efficacy and success of the CPD.

Moreover, the most cited attributes in research are regulatory ones, which comprise the nucleus of any construction delivery strategy, including governance and administration, design approach, risk allocation, cost and time determinants, legislative procedures, and finance approach. These principles govern construction contracts. The other attributes that convey normative or cultural–cognitive attributes follow the regulative attributes. The

normative category includes those attributes that standardise all the processes resulting in construction program deliverables conveying scope definability, technical clarity, economic influences, market status, resource workload, quality management, stakeholder influences, local and environmental preferences, and logistic approach. They are either prescriptive or proscriptive action guidelines. However, they cannot necessarily be appraised legitimately. The impact of cultural–cognitive attributes is less known in selecting a CPD strategy than other attributes in research. They include the expectations, motivations, and understanding of stakeholders, as well as the norms and values that shape the decision-making process. Cultural–cognitive qualities, including teamwork, institutional cognitive load and agency history, may simultaneously be able to impact selecting a type of delivery, directly or indirectly, such as other attributes.

A review of the existing literature and the findings have shown that both researchers and construction agencies have focused on regulatory and technical aspects embedded within social and economic contexts that convey normative and cultural constituents when addressing the delivery of construction programs. Regulatory attributes dominate CPD research. This might be due to the following reasons. First, most research focuses on measurable, quantifiable factors frequently subject to contractual obligations and government regulations. In contrast, using standardisation or cultural norms in research may be deemed less necessary because they are more context-specific and challenging to measure. Additionally, since regulatory factors have a clearly defined nature, and clear criteria for success or failure, they can be studied and analysed more efficiently, while normative and cultural elements may be challenging to isolate and quantify in research studies, making it more difficult to analyse their impact on CPDs.

4.3. Discussion

It is revealed that eighteen attributes influence the CPD strategy selection, indicating that the decision-making process is a complex procedure. Nevertheless, this list is intended only to provide decision makers with the opportunity to conduct a comprehensive review of required delivery attributes regarding the construction program or to serve as an ancillary tool for making decisions. Throughout this article, the attributes have been ranked according to how frequently the researchers address them. Nevertheless, the frequency of citations does not represent the importance of the attributes when choosing a strategy in practice; it only indicates the degree to which the researchers have emphasised the significance of a particular attribute. An in-depth examination of these factors is necessary to make a more informed decision regarding the CPD selection method.

The interrelationships among the delivery attributes should be examined. These interrelationships should be considered when any existing delivery strategies are chosen as the delivery framework. Neither attribute exists independently nor is unrelated to the other, but they are interrelated and may have either a positive or negative interaction [101]. Moreover, choosing a delivery strategy should also take into account attributes' interdependencies; according to [2], three types of interdependencies were identified: pooled, sequential, and reciprocal to explain interrelations among London 2012 Olympics CPD attributes. A pooled interdependency occurs when the delivery attributes are discrete and play their own roles. A sequential interdependency occurs when one component's output becomes another component's input. In a reciprocally interdependent system, the inputs and outputs of units are derived from each other. They argued that all the mentioned interdependencies exist in all construction program types. When the design of a structure is altered, it may affect the schedule for the construction process (sequential interdependency) or the logistics required for construction (pooled interdependency), for example. This interrelation can also be explained through causal relationships among CPD attributes. Identifying causal relationships provides researchers with a powerful tool for examining the interrelationships between various factors that impact the delivery phase. By studying these relationships, researchers are able to identify how changes to one aspect of a project can affect the success of other aspects. Furthermore, this typology is intended to improve

communication and collaboration among the different parties involved in the construction process. The parties need to identify the interdependencies between the different attributes so that they can discuss the project's requirements and potential impacts using a common language. Therefore, the typology would help justify delivery attributes' interrelation and increase potential changes prediction in temporary structures.

A great deal of complexity is involved in selecting a CPD method. Construction program values, goals, and conditions would significantly influence the selection procedure [97]. Different delivery solutions offer different levels of speed, efficiency, and cost effectiveness. By considering the specific requirement of a construction program in terms of value, goals, and conditions, it is possible to make an informed decision on the best delivery solution for that program.

Construction programs have specific qualities in common. Any construction program is characterised by a high level of complexity [39]. Some scholars consider complexity a separate delivery attribute [42,81]; however, they have recently attempted to open up new managerial horizons to enhance an organisation's ability in order to utilise capabilities and knowledge efficiently and explore strategies for reciprocating flexibly concerning the inherent complexity of CPD [29]. A structure was represented by [111] to find out complexity as an inherent part of any large-scale project by breaking it down (Figure 6). This tool allowed construction agencies and researchers to break down CPD complexity into smaller components and assign them different levels of complexity. The structure could address the hidden workload caused by complexity. As a result, the ancillary tool also gave users sensible foresight to efficiently plan the budget and schedule for a large-scale project by ascribing complexity to CPD attributes. The novel managerial paradigms developed by existing requirements have represented program management's evolutionary components distinct from conventional project management values and principles.

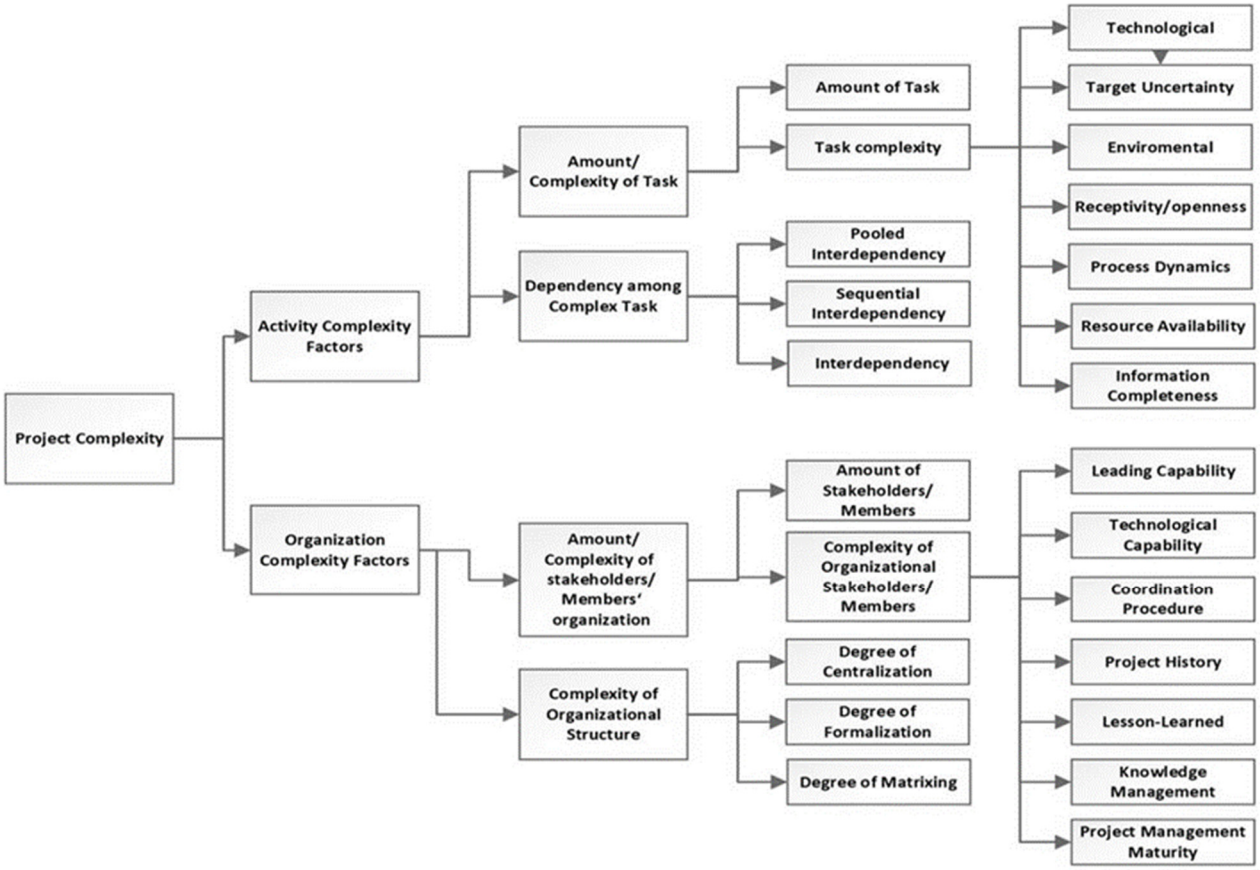

Figure 6. Complexity breakdown.

In the nuanced landscape of strategy selection for CPD phase, the synergistic interplay between attributes and complexities operates as an intellectual and practical nexus. This intricate causal matrix serves as a multidimensional lens, lending critical perspectives to CPD dynamics while adding an additional layer of analytical complexity. Commencing with governance and administration, they are not merely procedural elements but contingent upon the labyrinthine layers of organisational complexity, manifesting prominently in decision-making hierarchies and governance protocols. Risk allocation, another pivotal attribute, is intricately connected to activity complexity, specifically regarding task dependencies and their interconnected risk landscape. The concept of the financial approach is further nuanced by its causal relationship with economic factors and prevailing market conditions, aggravating both activity and organisational complexities. In a similar vein, scope definability and technical clarity function as catalysts in the evolving complex environment of CPD. Their direct and indirect correlations with task magnitude, degree of task complexity, and stakeholder multiplicity enrich the texture of the already intricate project tapestry. Legislative procedures find their orientation within the framework of stakeholder complexities, especially when entangled with governmental and regulatory entities. Consequently, stakeholder influences and interventions become indicators of and contributors to organisational complexity. The operational domains of quality management, resource workload, and logistics are profoundly interwoven with both activity and organisational complexities. Even the often-overlooked institutional cognitive load finds its significance accentuated within the maze of organisational intricacies. Concomitantly, agency history and teamwork act as the culminating attributes, being sensitive to a myriad of complexities, both in terms of activities and organisational structures. Their significance lies in harmonising collaborative efforts across a tapestry of intricate tasks and a composite of diverse stakeholders. The dialectical interplay between CPD attributes and complexities underscores the critical need for an integrated analytical framework and enriches scholarly understanding. This symbiotic relationship amplifies the analytical rigour, thus contributing to the genesis of robust methodologies and best practices in this complex and ever-evolving field. The causal interrelationships, the correlation among CPD attributes that either mitigate or amplify complexities, and the ensuing uncertainty, necessitate a layered, multifaceted approach to strategy selection and implementation. Such an integrated perspective allows for advanced strategic adaptations that effectively navigate the labyrinthine landscape of CPD.

Considering CPD attributes that influence the performance of the delivery strategy would assist in understanding and making a decision. A study of the influence mechanisms of attributes on performance will allow construction agencies to decide whether the factors and their leverage should be adopted. Research has been conducted on several attributes listed above, considering particular objectives and perspectives. For example, the influence of owner characteristics was discussed by [72]. However, there is evidence that the influence of some features that have not received typical attention, like the organisation executing the program should also be studied in more detail [81]. The iron triangle objectives received the most citations in research regarding CPD. However, the relationship between these regulatory elements and other features, like normative and cultural, must also be examined. In other words, the iron triangle should not be seen as an isolated phenomenon but as part of a more extensive system of factors influencing CPD. The interplay between normative and cultural elements and the iron triangle in a socio-economic context may help explain a project's success or failure. In addition to considering the inherent features of construction programs, such as complexity and uncertainty, any integral model for selecting a delivery strategy should also examine the attributes' causality and their interrelationship simultaneously. Comparing the casualties and correlations among attributes in the CPD would help identify the most suitable delivery strategy.

5. Conclusions, Limitations and Future Research

The study primarily aimed to analyse the current literature to identify gaps and nuclei, as well as directions and trends for future research. Findings showed that a systematic analysis of the attributes associated with selecting a delivery strategy for a construction program has not been comprehensively undertaken. Thus, the research aimed to identify the main attributes driving CPD method selection using a systematic review, including a bibliometric analysis over the current century.

The paper first elaborated on current research trends and gaps in the delivery context regarding CPD. The bibliometric analysis recognised the dominant sources of CPD publications, countries, and growth trajectory. Three-plot Sankey graphs demonstrated the relations among CPD top authors, the countries which contributed to CPD research significantly, CPD focused areas, and utilised keywords in the literature. Possible explanations were then interrogated based on findings. A CPD research collaboration map among authors, institutions, and countries was then shown. The CPD research analysis identified four dominant pairs of collaboration relationships around the globe, including Australia–China as the most compelling. There is a possibility that this finding may be attributed to the shared interests between the two countries in developing economic and social stability in the region, the commitment to strengthen international trade and investment, and to the cultural and economic ties. Finally, a histogram of research trends in CPD contextualisation was provided to highlight changes in research focus over the lifespan. As a result, research trends among the utilised delivery strategies, the emerging program management paradigm like institutional theory, and the recognition of some cultural–cognitive delivery attributes which have been studied in recent years, have been identified as the most important context in terms of CPD research.

Conducting the bibliometric analysis also disclosed that delivery attributes and CSFs were two primary contexts that scholars focused on in terms of CPD planning. Based on text analysis among 40 journal papers, the most significant CPD attributes were categorised into 18 groups and 74 sub-categories. The relative importance of each group and sub-category was evaluated based on the citations. As a result of the rankings, regulatory attributes such as risk management, cost and time determinants, the design management approach, financial approach, and legislative procedures received higher leverage than normative and cultural constituents. Ultimately the possible reasons were discussed.

Moreover, there is no one-size-fits-all strategy in terms of CPD [41,93,94,97,100,112]. Thus, the study discussed an integral approach for selecting a delivery strategy for a construction program that should assess complexity and uncertainty besides determining the attributes' causality and interrelation. This analysis and model based on noted variables can be research topics for further assessments.

Several limitations are inherent in the current study. Future research and reviews can be conducted to minimise these limitations by scholars. This could involve expanding the scope of the study by including a more extensive range of publication in terms of source or conducting in-depth interviews with experts to explore the topic thoroughly. It could also involve collecting more data over a longer period of time to monitor any changes in a certain CPD trend. Limitations include the following:

- Due to the limitations of the Bibliometrix software concerning data input characters, only peer-reviewed journal publications conducted in the recent century were considered in this review. Reviews conducted over a long period as well as other resources like conference papers, can provide further analysis and interpretation.
- This study aims to better understand delivery attributes by providing an auxiliary tool for analysing them, so only papers concerning CPD were analysed.
- This study was a systematic review of delivery attributes for construction programs; therefore, this study did not focus on a specific type. The findings of this study could be used as a basis for further quantitative or qualitative research.
- The review examined the current delivery attributes and considerations affecting the delivery planning process. It is highly probable that regulatory, cultural, and

standardisation norm changes due to cultural shifts or environmental concerns, for example, will alter the list.

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