Review

Claim Management and Dispute Resolution in the Construction Industry: Current Research Trends Using Novel Technologies

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Review

Claim management and Dispute Resolution in the Construction Industry: Current Research Trends Using Novel Technologies

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Abstract: Claims arising frequently in the Architecture, Engineering and Construction (AEC) industry usually result in disputes, leading to all sorts of negative implications for a project. Claims need to be managed efficiently, and in case they evolve into disputes, they need to be resolved as soon as possible so that the construction process can resume. In this paper, a bibliometric review is carried out to explore the existing literature regarding construction claims and dispute resolution methods employed in construction projects. Using VOSviewer and the Scopus database, relevant literature is retrieved and analyzed using keyword searches, including "construction claim" and "construction management". The detected research themes provide future researchers with potential research directions. A gap in the research regarding the emergence of terms such as "blockchain", "smart contracts", and "building information modelling (BIM)" appearing only recently after 2020 in the literature regarding the construction claims and disputes research area was determined. Therefore, a content analysis of the most recent publications employing these and other novel technologies is conveyed. Ultimately, the main research trends and potential research directions for assisting researchers and construction professionals in their efforts to address construction claims and disputes in sustainable and efficient ways are discussed.

Keywords: construction claim; construction dispute; claim management; dispute resolution; BIM; Blockchain; smart contract

1. Introduction

In every agreement where multiple parties are involved, disputes appear as a natural phenomenon, even if the surrounding conditions are perfect [1]. Accordingly, the case could not be any different in the construction industry, where an extremely complex and multidimensional environment is observed, and various professionals are involved during a construction project [1–3]. Cheung and Yiu [4] argue that dealing with disputes is part of an engineering manager's portfolio. The stakeholders responsible for the emergence of conflicts, claims and disputes in the process of a construction project are the owner, the consultant engineer and the contractor or subcontractors [3]. As Naji *et al.* [5] observe, the terms conflict, claim or dispute are often mentioned in the relevant literature as synonyms, despite this not being entirely accurate. A conflict arises when the same situation is viewed differently according to each involved stakeholder's perspective [5]. According to Mishmish and El-Sayegh [6], a claim can be defined as a request for compensation for damages incurred by any party to the contract and can refer to either a time extension or money reimbursement. In case a claim is made by one party and rejected by the other, then this situation results in a dispute [2,7], which needs to be resolved in order for the construction process to resume. Therefore, the submission and rejection of a claim can be seen as the start of dispute evolution [5].

Disputes arising in the construction industry induce negative impacts on a construction project since they require resources which could be spent more productively [2], lead to cost and time overruns [1–3,6,8], and could also generate problems in the involving parties' working relations,

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which could even cause these relations to rupture [2,6]. The causes for such claims and disputes have been thoroughly investigated throughout the literature, and a variety of classifications and taxonomies exist. The categorization presented by Cakmak and Cakmak [9] revealed that there are seven main causes of claims related to the contracting authority (owner), the contractor, the design, the contract, human behaviour, the project, and external factors. Figure 1 presents a risk breakdown structure of 39 causes of claims (risk factors), which provides a comprehensive view of the hierarchy of the predominant causes of claims based on Cakmak and Cakmak's categorization, as were studied in the research by Antoniou and Tsioulpa [10], resulting in a Causes of Claims Breakdown Structure (CCBS). Remarkably, the causes leading to construction claims and disputes have not changed significantly throughout the years [1]. According to the 2021 ARCADIS report [11], the overall dispute cause for the year 2021 was that the owner/contractor/subcontractor failed to understand and/or comply with its contractual obligations. This situation, along with the issue of poor claims documentation, are considered the two main reasons for construction disputes [1].

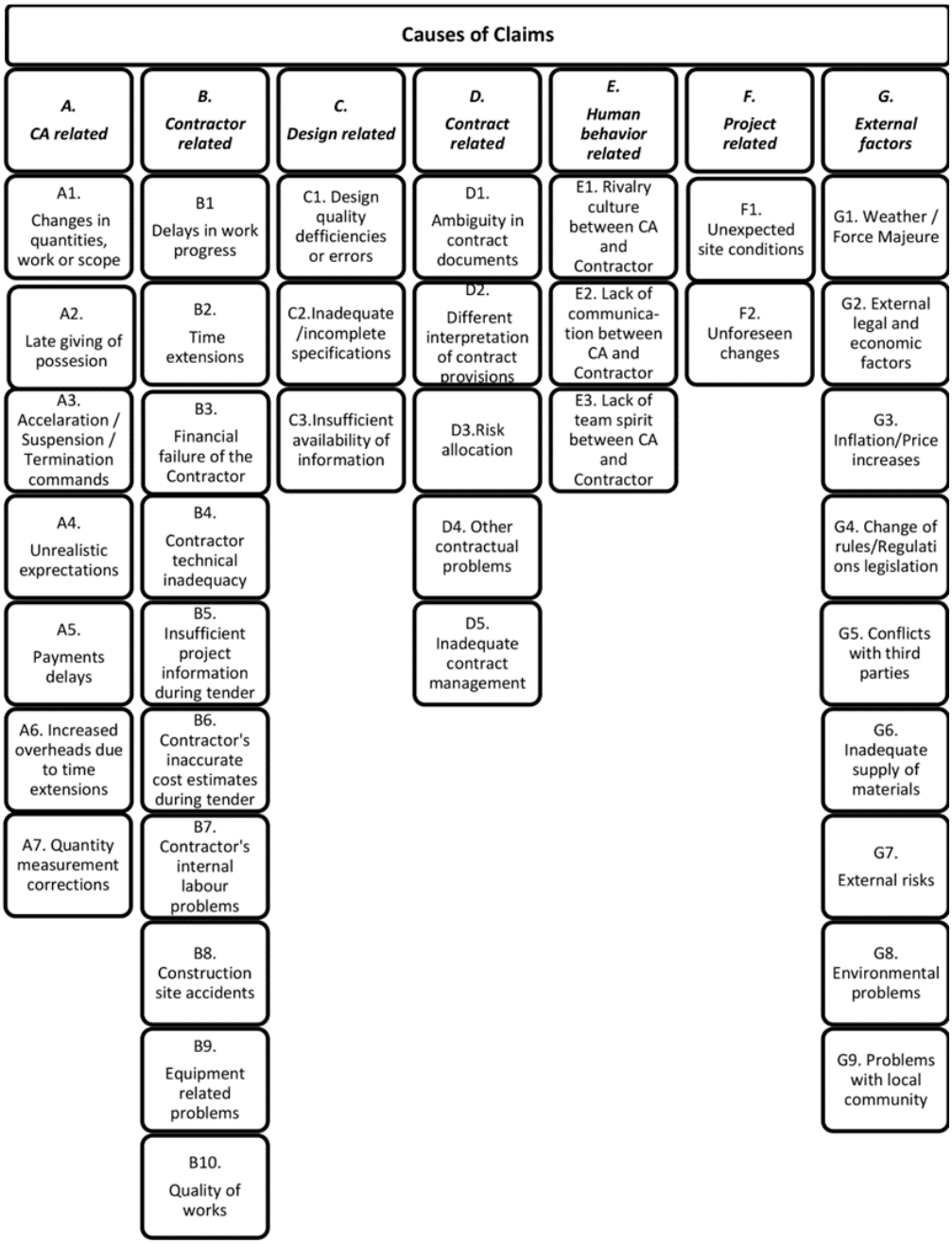

Figure 1. Causes of Claims Breakdown Structure (CCBS) [10].

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As stated before, whenever such disputes occur, the construction process inevitably pauses, and corresponding actions should be taken so that the disputes are resolved, and the process may resume. Disputes in the construction environment may be resolved by various methods, such as negotiation, litigation, arbitration, mediation, or any alternative dispute resolution method [2,8,11]. Litigation at courts, the traditional dispute resolution method used by public owners [8], is considered a time- and cost-consuming method [2], and private owners prefer the alternative dispute resolution methods (ADR) [8].

The purpose of this perspective paper is to explore the current research trends regarding claim management and dispute resolution in the construction industry, identify any research gaps and provide suggestions for future research directions in order to assist researchers and construction professionals in their efforts to address more efficiently construction disputes and their negative impacts on project performance.

Following this introductory section, section 2 describes the approach used to conduct this research, and section 3 presents the results with respect to the overall trend of research by publication year, journal, geographic location, co-authorship, and main research areas. Furthermore, a co-occurrence keyword analysis is conducted, revealing six main research themes, identifying the emergence of novel technologies such as BIM, Blockchain and Smart contract related to the investigation into claim management and dispute resolution in the construction industry, and, subsequently, a content analysis of the papers published during 2020-2022 is conveyed in section 4. Finally, the main research trends and potential research directions for enhancing claim management and dispute resolution practices in the construction industry are discussed in section 5. In section 6, the conclusions of this paper are presented, highlighting the most important findings of this research.

2. Methodology

This study adopts the science mapping technique in order to explore the existing literature regarding construction claims and dispute resolution methods employed in construction projects. The science mapping technique consists of bibliometric analysis, scientometrics and informatics; the bibliometric analysis focuses mainly on the literature per se, while scientometrics is used to measure and analyze the literature results, and, through informatics, these results can be visualized to detect not only the practices used by researchers, as well as the intellectual structure of a scientific field [12,13]. The publication and citation characteristics of construction claims and dispute resolution methods research were examined in terms of country, source, and author based on bibliographic coupling and citation analysis. Then, keyword co-occurrence analysis was conducted to detect the research topics and temporal trends, as well as the gap in research related to claims and dispute resolution methods in the construction industry. Finally, the authors performed a manual content analysis of the recently published studies related to this research field, allowing further analysis and classification of the current research trends regarding claim and dispute resolution methods in construction industry research.

Among the various existing science mapping tools, VOSviewer, BibExcel, CiteSpace, CoPalRed, Sci2, VantagePoint, and Gephi [12], VOSviewer was selected for this quantitative analysis as it is one of the most recommended mapping and visualization tools which can illustrate data obtained from bibliographic databases, such as Scopus or Web of Science, in a great visualized form and also has special features concerning text-mining [13]. Supplemental to VOSviewer, OpenRefine (version 3.5) software was also employed to improve the data obtained from the selected bibliographic database along with a thesaurus file. This procedure resulted in correcting errors and typos, as well as arranging similar terms into clusters regarding the co–occurrence author keyword analysis.

The Scopus (Elsevier) database was selected among the alternative available academic digital databases for scientometric analysis due to it being one of the most comprehensive ones, including a greater number and broader range of indexed publications in the engineering discipline and being more user-friendly [14] compared to the Web of Science database, without presenting double citation counting problems as is often the case with the Google Scholar database. The following statement was entered on the Advanced Search area in Scopus: TITLE-ABS-KEY (disput*) OR TITLE-ABS-KEY

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("construction claim*") AND ALL ("construction management"). The wildcard "*" denotes the fuzzy search strategy that is used to capture term variation [15]. After this initial search, the results were then filtered in order to select journal articles and papers published in conference proceedings written in English. Finally, this approach resulted in retrieving 791 documents, including 543 journal articles (69%) and 248 conference papers (31%), published between 1983 and 2022 (retrieved online on November 22, 2022), which were selected for this analysis.

The distribution of annual publications from 1983 to 2022 is shown in Figure 2, where it is easily observed that the number of annual publications started increasing after 2007 and, especially in the past five years, resulting in almost 43% of the entire relevant documents being published. The whole set of 791 publications received a total of 9,762 citations, an average of 12 citations per paper. The increasing number of published documents also indicates that claim management and dispute resolution in construction industry research has attracted extensive attention in the past fifteen years, indicating the importance of the impact claims possess in the construction industry.

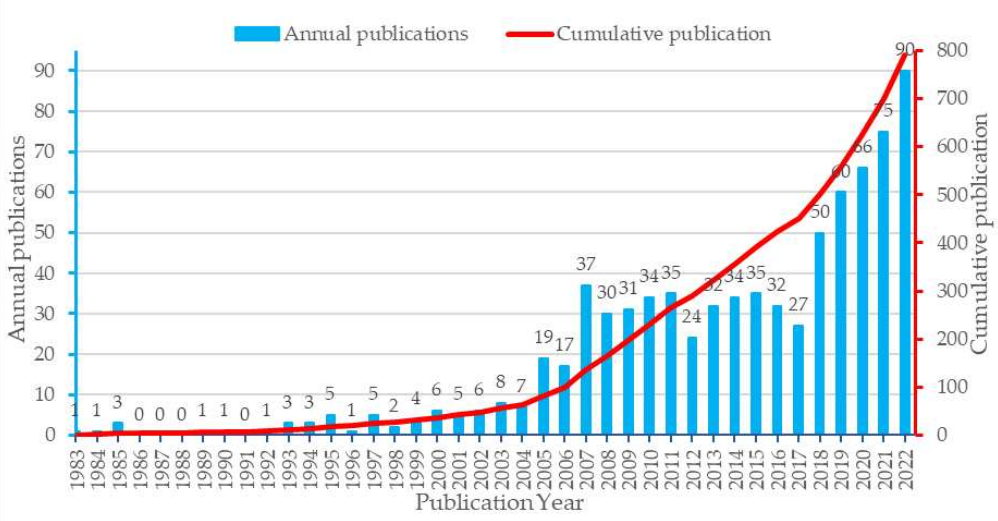

Figure 2. Distribution of the indexed research published between 1983 and November 22 2022.

Following the bibliometric analysis that was essential for determination, a content analysis of 27 research articles published in the past three years was conducted to determine the proposed future research directions. The widely accepted Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) method was followed for the selection of the studies for content analysis [16]. Figure 3 shows the adapted PRISMA flowchart of the process for the screening and selection of the relevant studies, which was conducted in four stages (identification, screening, eligibility, and inclusion).

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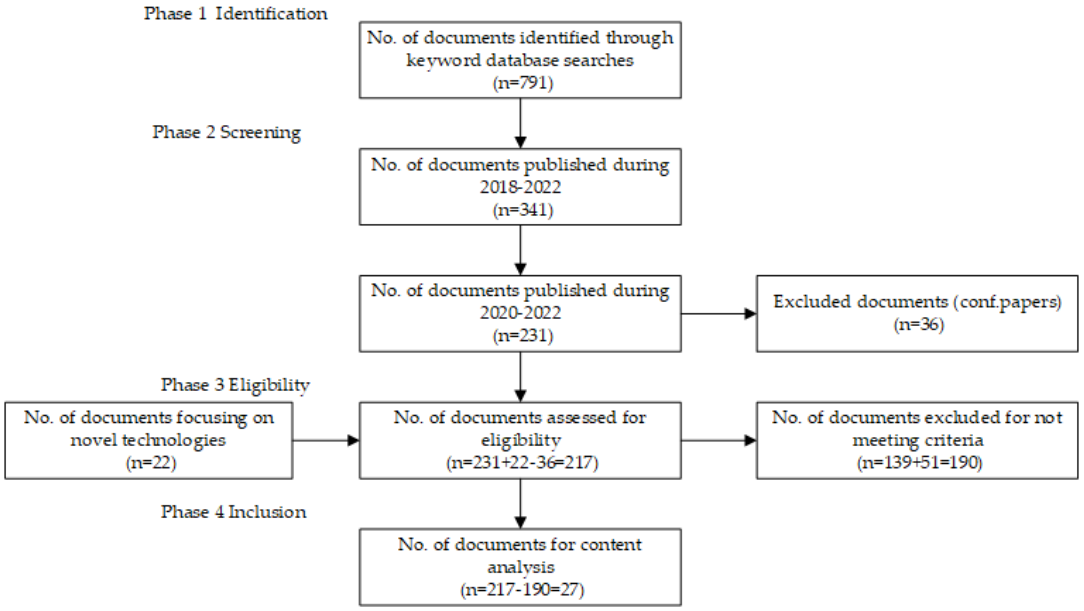

Figure 3. PRISMA flowchart for screening and selecting research documents.

3. Bibliometric Analysis

After selecting the data from the Scopus database, they were then exported in a .csv file (comma-separated values file) for further analysis through VOSviewer. This section presents the analyses carried out using VOSviewer to detect the most influential countries, the top highly cited publications sources (journals and conference proceedings), the most prominent researchers and authors and the main research areas.

The analyses carried out employing VOSviewer produce maps, which normally contain only one type of item (i.e., publications, researchers, countries, terms, or sources) and the potential relations or connections between any pair of items are called links, such as bibliographic coupling links between countries, or co-occurrence links between terms, etc. A map typically includes only one type of link. Any pair of items can be connected with only one link, which has a strength represented by a positive numerical value. The higher the value, the stronger the link. For instance, in the case of co-occurrence links between two terms, the strength of a link indicates the number of publications in which two terms occur together. Items and their links constitute a network. Items can have weight and score attributes, which are presented by numerical values. Weight attributes indicate the importance of an item, and there are two standard weight attributes· Links and Total link strength. The Links attribute shows the number of links of an item with other items, whereas the Total link strength indicates the total strength of the links of an item with other items. Presenting the abovementioned basic terms is essential to understand the following results produced via the VOSviewer software [17].

3.1. Country analysis

All construction projects are prone to conflict [18]. The reasons for the claims occurring due to such conflicts, as well as the means of resolving these disputes, are researched throughout the world. In order to identify the most significant contributions of a country in this research field, the type of analysis was selected as bibliographing coupling, meaning the relatedness of countries is determined based on the number of references they share [17], with the limitation of at least five documents per country. As a result, of the 65 countries where at least one relevant study has been published, 31 met the threshold. The magnitudes concerning documents, citations, average citations per document and total link strength with respect to the five most influential countries, Australia, Hong Kong, USA,

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United Kingdom, and China, are illustrated in Table 1. At the same time, all 31 of them are shown in Figure 4, visualized in 5 groups (clusters).

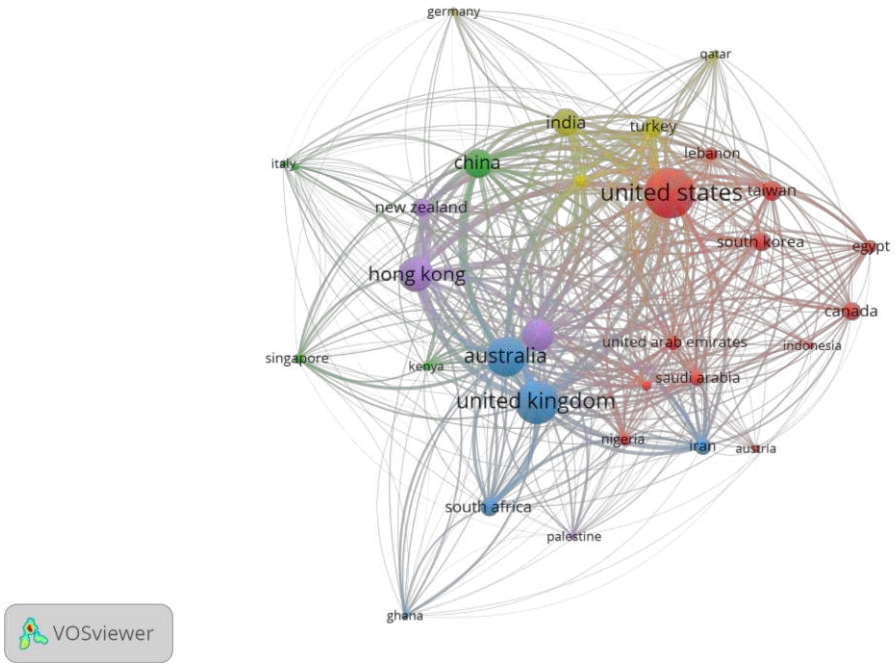

Figure 3. Most influential countries during 1983-2022.

Table 1. The magnitudes concerning document and citation as per countries.

ID	Country	Documents	Citations	Avg. Citations	Total Link Strength
1	Australia	90	1294	14	12896
2	Hong Kong	74	2322	31	11374
3	United States of America	137	2102	15	10663
4	United Kingdom	107	1374	13	10634
5	China	54	1032	19	8797

3.2. Publication sources analysis

In total, 791 papers were published in 218 journals and conference proceedings according to the citation analysis, meaning the relatedness of the publication sources is determined based on the number of times they cite each other [17]. The limitations this time were that at least 1 document must have been published from each source, and also, this source must have been cited at least five times. Of the 218 sources, 106 met these thresholds. The latter's top 5 according to Total Link Strength, which indicates the total strength of the links of the journals with other journals, are illustrated in Table 2, along with data concerning published documents, citations, total link strength and Scopus Quartile per source, according to November 2022 SCImago Journal Rank (SJR) statistics. "The Journal of Legal Affairs and Dispute Resolution in Engineering and Construction" has published the most documents (84 articles), and the journals "Journal of Construction Engineering and Management" and "Construction Management and Economics" contribute the most to this research field in terms of their total link strength.

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Table 2. Top 5 Journals according to Total Link Strength.

ID	Journals	Documents	Citations	Total Link Strength	Scopus Quartile
1	Journal of Construction Engineering and Management	82	2538	331	Q1
2	Construction Management and Economics	42	1222	207	Q1
3	Journal of Legal Affairs and Dispute Resolution in Engineering and Construction	84	490	195	Q1
4	Engineering, Construction and Architectural Management	31	428	161	Q1
5	Automation in Construction	19	678	79	Q1

3.3. Author analysis

Over the investigative period, a total of 1512 authors have published at least one paper related to the examined research field. Attempting to detect the researchers who have contributed the most to the research regarding claim management and dispute resolution in the construction industry, citation analysis was conducted through VOSviewer software, selecting "Authors" as the unit of analysis, meaning the relatedness of the authors is determined based on the number of times they cite each other. The thresholds this time were that each author had at least five papers published and had been cited at least five times. These limitations resulted in detecting 38 authors, with 37 of them being connected, as illustrated in Figure 5.

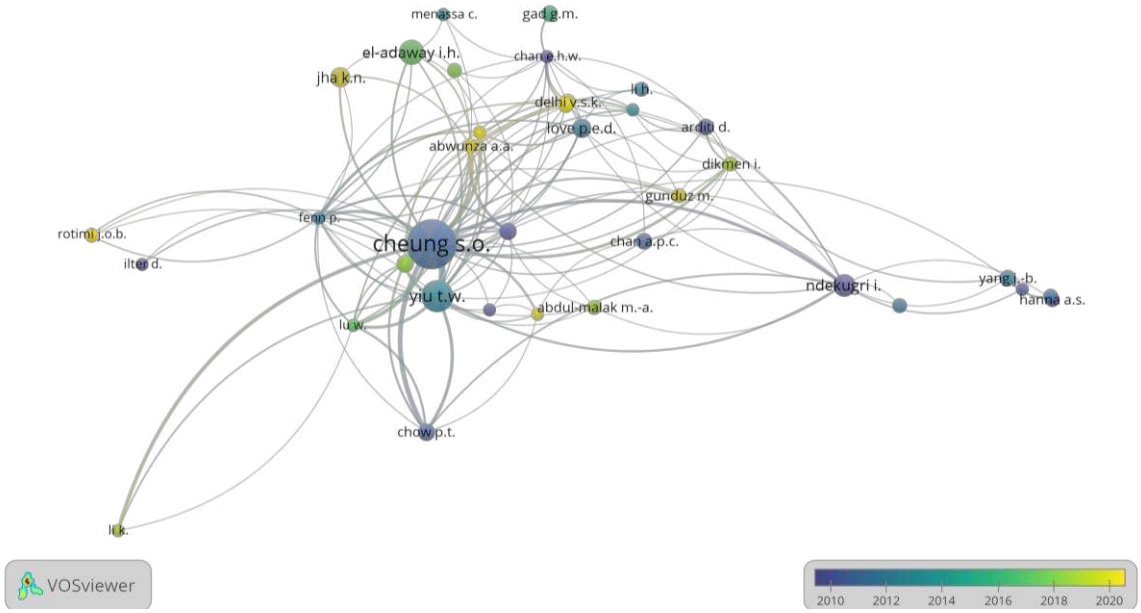

Figure 4. Magnitudes of the published documents as per the authors per average publication year.

VOSviewer software provides the tool to map the selected network of authors according to the average years concerning the papers they have published, translated in colour. In particular, the authors highlighted in yellow are the ones having published more recent publications (i.e., Gunduz M. and Abwunza A.A.). In contrast, the authors highlighted in green, blue, and purple are those having relatively earlier contributions to the examined field (i.e., Cheung S.O., Love P.E.D. and El-Adaway I.H.). Table 3 illustrates the number of the top 5 authors' papers related to this research field and the number of citations, sorted as per total link strength. In Table 3, one can observe that Cheung S.O. has published the most papers related to the examined field (45), and Yiu T.W. and Fenn P. were the ones whose publications had the highest number of average citations.

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Table 3. Documents and citations per authors.

ID	Author	Documents	Citations	Avg. Citations	Total Link Strength
1	Cheung S.O.	45	1131	25	238
2	Yiu T.W.	21	363	17	125
3	Chow P.T.	8	102	13	56
4	Fenn P.	5	168	34	52
5	Zhang L.	8	86	11	50

3.4. Main research areas (co-occurrence of keywords analysis)

For the keyword analysis of this study, a co-occurrence network of author keywords was created using VOSviewer. Applying this type of analysis means that the relatedness between keywords is determined based on the number of publications in which they occur together [17]. Mapping a network of related keywords, through which the core content of published papers is represented, provides researchers with an accurate picture of scientific knowledge production in terms of patterns, relationships, and intellectual organization of the research themes covered [12]. VOSviewer created the network by setting the minimum number of occurrences of a keyword to 10 after supplementary data processing via OpenRefine, and a thesaurus file was created according to the initial results of the keyword analysis. The purpose of this data processing lies in merging similar terms, as well as correcting errors and typos of terms.

This process resulted in the network being visualized in two forms in Figures 6 and 7. The network consists of 52 nodes (keywords) and 583 links organized in 5 clusters. The visualization in Figure 6 is per average publication year, whereas the one in Figure 7 is a density visualization map. The size of each point depends on the density of the number of items at that point, and the keywords in the different clusters are displayed in different background colours. Furthermore, keywords that are grouped into the same cluster may reflect more related research areas [19] and the keywords "construction disputes and conflicts" and "claims and disputes" are, as was expected, the most repeated ones, interconnecting all 5 clusters. Both visualizations reveal that the terms "blockchain", "smart contracts", "building information modelling (BIM)," and "claim management" appear only recently in the past three years in the literature with regards to construction claims and disputes research area. Attempting to shed light on the manner in which these concepts relate to construction claims and disputes, the recent documents published during the last three years were further investigated, leading to the content analysis described in the next section.

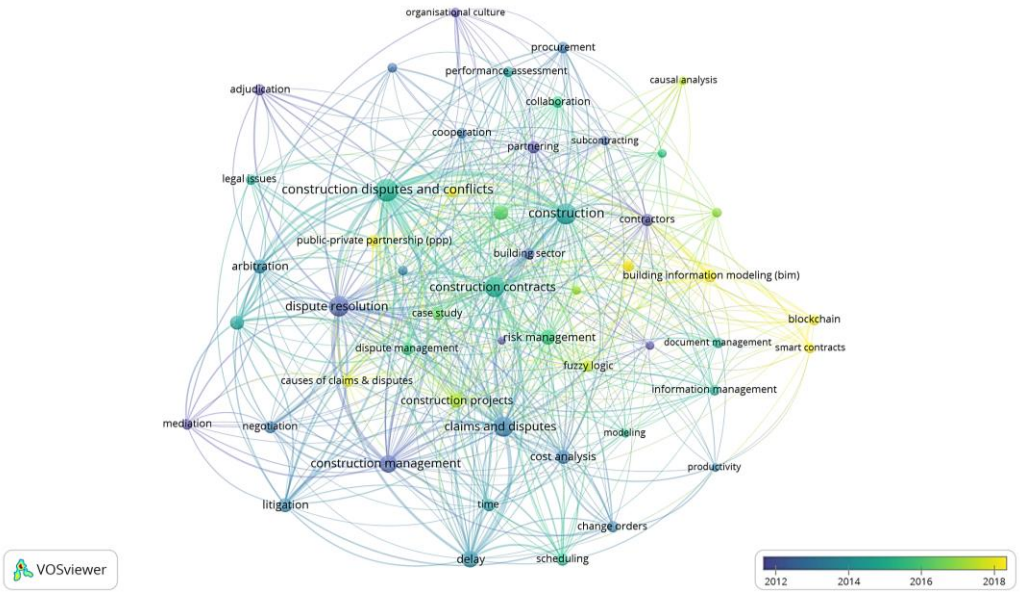

Figure 5. Main keywords repeated in documents per average publication year.

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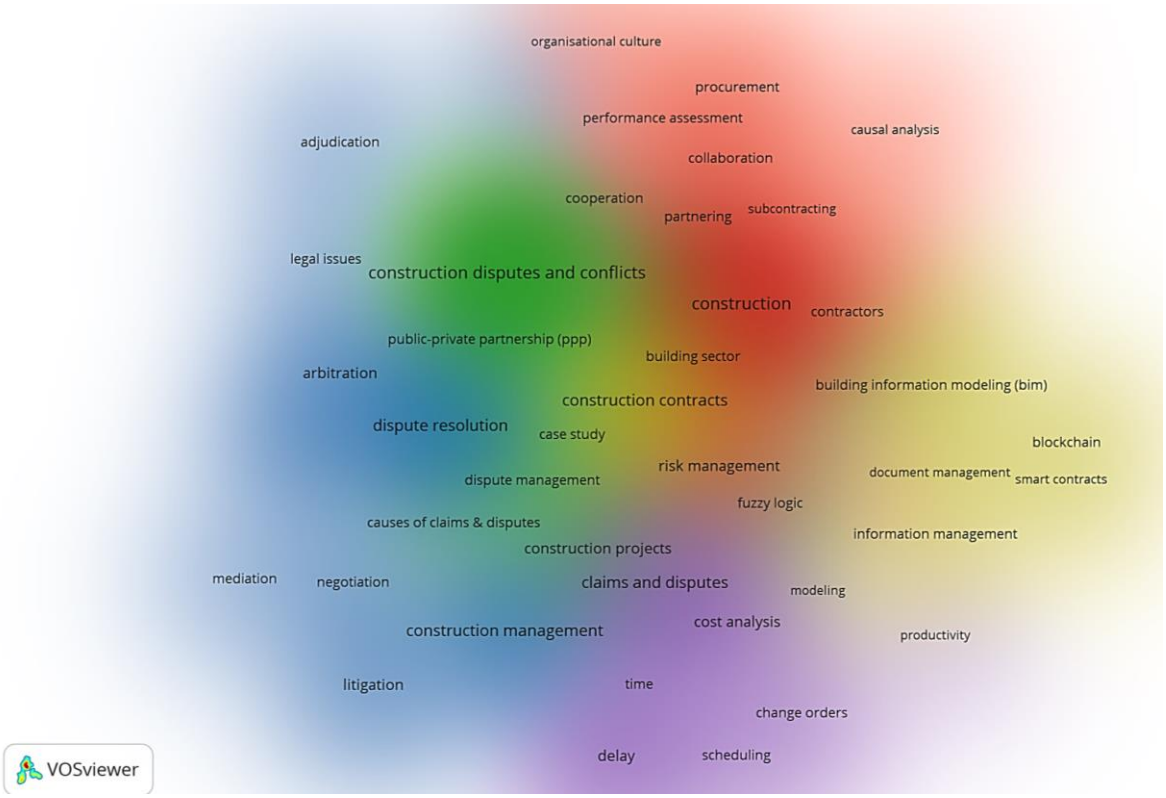

Figure 6. Main keywords repeated in documents grouped in 5 clusters.

4. Content analysis of the most recent publications

As was revealed in Figure 2, a significant amount (341 documents) of the related literature was published during the last five years, indicating the researchers' growth of interest in this research field. Conducting a preliminary screening of the 231 journal articles and conference papers published during 2020-2022 with regards to the research theme, 6 subcategories emerged, as listed below.

1. Assessment of factors leading to claims/disputes
2. The role of the human factor in construction conflicts
3. Construction project performance
4. Dispute resolution methods' assessment
5. Claims/Dispute management process models
6. Methods for modelling and evaluating construction disputes.

The abovementioned 231 journal articles and conference papers were further shortlisted considering the publication and citation patterns revealed in section 3 as well, resulting in 27 journal articles for further investigation based on the following inclusion and exclusion criteria:

- The publication type must be a journal article (36 conference papers excluded).
- Studies focusing on novel technologies, such as BIM, blockchain and smart contracts (22 documents included)
- Journal articles cited at least five times except for those focusing on novel technologies (139 documents excluded)
- Journal articles being published in any of the top 5 journals presented in Table 2 and/or authored by any of the most prominent authors presented in Table 3 (51 documents excluded).

The first exclusion criterion was applied due to conference papers usually being less detailed than journal articles and therefore omitted in review papers [20]. The second inclusion criterion was chosen to investigate how these recently emerged terms are associated with construction claims and disputes, as was revealed in subsection 3.4. The third exclusion criterion was applied following the

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publication and citation patterns and thresholds selected during the bibliometric analysis conducted in subsection 3. In this step of the selection process, the threshold of 5 citations per paper was not applied for the studies focusing on novel technologies, as they have only recently emerged in the literature. The fourth and final exclusion criterion was selected to detect the main research trends, gaps, and future research directions based on the results of subsections 3.2 and 3.3. Some of the most important findings of these 27 selected publications are presented per research theme in the following subsections in table form.

4.1. Assessment of factors leading to claims/disputes

Various studies have investigated the causes of construction disputes throughout the world, focusing either on specific construction projects (i.e., road projects [21,22] or on the construction sector in general [23], as well as investigating either all types of causes [23–25] or a particular type (i.e., variations [21,26]).

It is worth noting that while in the past relevant studies focused on identifying long lists of claim/dispute causes [27], the focus of recent studies lies on examining the interrelationships between various factors affecting the emergence of claims and disputes, aiming to discover possible patterns of claim occurrence and making suggestions to address such factors before evolving into disputes, thus enhancing claim management [21,22,26–29]. Further details to better comprehend this recent swift focus on construction claims research can be found in Table 4.

Table 4. Assessment of factors leading to claims/disputes.

Ref.	Project type/ Sector	Country	Causes of claims/ disputes	Other findings
[23]	Construction sector, in general	United Arab Emirates (UAE)	1. variations initiated by the owner 2. obtaining permit/approval from the municipality and other governmental authorities 3. material change and approval during the construction phase 4. the slowness of the owner in decision-making 5. short time available during the design phase	• negotiation was the most effective dispute-resolution method • litigation or settlement in court was the least desired by all entities
[24]	residential/ commercial buildings – **highest % among all other types** water & sewer lines roads & highways power plants hospitals airports	United Arab Emirates (UAE)	1. change/variation orders 2. delay caused by the owner 3. changes in material and labour costs 4. variations in quantities 5. low contract price due to high competition 6. delay in payments by the owner 7. poorly written contracts	• using the PPP (Public-Private Partnership) concept to share risk between owner & contractor • using the ADR method to resolve claims before going for litigation
[26]	Building construction projects (lump sum & design-bid-build)	North Cyprus Turkey USA	**Change** factors – Categories 1. Planning & design (i.e., inconsistencies between different designs) 2. Construction & site (i.e., additions/omissions of work items) 3. Human factors (i.e., lack of experience of project participants) 4. Administrative (i.e., low contract price - competitive bidding) 5. External (i.e., shortening/compression of project schedule)	• Contractors' – Consultants' and Owners' views vary according to the different countries -regions • Nevertheless, better preparation of project documents and comprehensive organization prior to construction execution could significantly lead to reducing the necessity for change.
[21]	Road projects	Sri Lanka	**Root** causes of **variations** 1. Inadequate client brief/objectives 2. Differing site conditions 3. Design changes 4. Poor workmanship	**Suggestions** to reduce/manage potential variation-related disputes

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Ref.	Project type/ Sector	Country	Causes of claims/ disputes	Other findings
			5. Poor procurement process 6. Unavailability of equipment **Proximate** causes of **variation**-related disputes 1. Disagreement on the quantities 2. Disagreement on the scope of omission 3. Lack of Engineer's instructions to proceed with a variation 4. Disputes on the new rates 5. Disagreement on the interpretation of contract clauses	• Placing greater emphasis on planning and documenting the scope • Behavioural assessment of project team members • Detailed evaluation of site conditions by the parties to the contract • Fully defined scope • Design reviews and audits
[25]	Modular construction projects	USA	1. Payment holds and delays 2. Delay in project completion 3. Poor communication among the project stakeholders 4. Lack of collaboration between various trades	• modular construction disputes are mostly triggered by the occurrence of multiple causes rather than by just a single cause • **Future research** on the necessary, appropriate adjustments of the contractual aspects of modularization in construction
[29]	n/a	n/a	**Contract Readability risks** 1. Unnecessary complexity in using nouns 2. Use of abstract and ambiguous words or sentences leading to multiple interpretations 3. Unnecessarily long sentence length	• Improved readability can potentially lead to reduced conflicts, claims, and disputes in construction projects.
[22]	Road Projects (Transport PPP Sector)	India	1. Issues related to land acquisition 2. Issues related to environmental and other forms of approval	**Recommendations to avoid disputes** • Contract provisions need to be project-specific to the greatest possible extent. • Strict enforcement of contract provisions and compliance with the obligations by the respective public authority and private partner

4.2. The role of the human factor in construction conflicts

According to the CCBS shown in Figure 1, human factor-related disputes can emerge due to rivalry (adversarial or controversial), cultural differences, lack of communication or lack of team spirit between the CA and the Contractor. This situation is only natural since construction projects are complex not only because of specific technical project characteristics, but mainly because multiple stakeholders holding different perceptions and roles regarding the project must work together [1–3]. The human factor is also one of the deciding factors when it comes to dispute resolution, as it is not uncommon to find disputants missing the chance of capturing win-win options even when these are notable [30–32]. Additionally, as engineering professionals are involved in managing claims and disputes arising under construction contracts, it is vital to understand the spectrum of the enhanced claim administration roles that engineers are called to exercise and the necessary traits, practices, and requirements that are observed when these roles are fulfilled [33].

In the current subsection, recent studies attempting to explore in detail how the human factor affects construction conflicts are examined. Table 5 presents some of the most characteristic recent studies related to the domain of human factor in construction claims and their findings, revealing that the effects of the human factor can be observed early on during the procurement phase of a project [34], during other stages of the project life-cycle as far as building construction projects are

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concerned (design, construction, services installation, maintenance) [35], or at the early stages of the claim evolution process [33].

Table 5. The role of the human factor in construction conflicts.

Ref.	Project type/ Sector	Project phase	Factors affecting construction conflicts	Other findings
[34]	Construction sector, in general	Procurement	Unethical practices of bid shopping and peddling during the subcontractor (Subs) procurement process	• Development of a blockchain-enabled smart contract system to establish that the subcontracting procurement process is grounded on system-based trust. • The proposed framework prevents these unethical practices and enables Subs to fairly compete for bid awards with proper budgets. • Trust between the general contractor and Subs can be enhanced via the proposed framework.
[35]	Building construction projects	Design, Construction, Services installations, Maintenance	Practices of reactive devaluation (RD), a cause of disputants' irrational decisions which affect construction dispute negotiation (CDN)	RD behaviours in CDN: • Reluctance to change • Doubts about counterpart's ability • Overconfidence • Biased information processing • Mistrust toward the counterpart
[33]	Construction sector in general – through the 2017 FIDIC contract conditions' scope	Early stage of the claim evolution process	**Identified Engineer's traits** 1. Objectivity 2. Impartiality 3. Standard of care 4. Professionalism 5. Due diligence	• The Engineer's consultative and decision-making roles can be distinctly viewed to mimic those undertaken by mediators and arbitrators, respectively. • The contract engineer is required to act neutrally and be prepared to act as a mediator when performing the consultative role and as an arbitrator when rendering a fair determination.
[36]	Construction sector, in general	n/a	**Contractor's reduced potential to disputes affected by:** 1. The contractor's perceived fairness during the process of administrating the project's claims and 2. Decision outcome considering the following variables (through engineering ethics' scope): **a. Fairness** *b.* Outcome favorability *(found not significant)* **c. Procedural fairness** **d. Quality of treatment-experienced** e. Quality of the decision-making process *(found not significant)* **f. Control**	• By investigating the stakeholders' perceived fairness, their nature to cooperate is also examined. • Highlighting perceived fairness to the contractor's behaviour. • National culture may influence the relationships hypothesized in the conceptual model of this research – future research involving participants from countries other than Pakistan is suggested.

4.3. Construction project performance

The main effects of claims and disputes in construction projects are increased project costs and time. Thus, claims can have significant impacts on the project's performance and the project's success or failure. Therefore, it is imperative not only to identify the causes of claims but to resolve them efficiently as well as to improve the project performance so that the projects can be completed in the

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scheduled cost and time [7,23]. In fact, this research team has recently completed research that pioneers by simultaneously examining the views of experts on the frequency of occurrence of causes of contractual claims and their perceived impact on the time, total cost, and quality of the final project [10].To this end, the current part of this paper presents, in Table 6, the most recent studies investigating the factors that affect construction projects' performance and could result in claims and, ultimately, disputes.

Table 6. Construction project performance

Ref.	Factors affecting project performance	Methodology	Important findings
[37]	• Construction Contract Administration (CCA)[1] process is one of the major causes of disputes in construction projects	• Development of a fuzzy structural equation model serving as a measurement tool for the CCA performance containing 11 project management process groups (constructs) and 93 key factors (indicators)	• The constructs and indicators related to claims and dispute resolution management were not ranked as the most important ones. • However, all the indicators identified within the study contribute significantly to the overall CCA performance, and no single item can be ignored.
[38]	• Lack of design liability control • Exposure of data to third parties • Data corruption and compromise in data privacy (using data for unintended purposes) • Data integrity (unauthorized access to sensitive data) • Data longevity	• Composition of conceptual process models that leverage Blockchain Technology for record-keeping of information exchange transactions. • A prototype system was designed to demonstrate and evaluate the proposed Blockchain integrated process models. • Three key project processes, design review, design coordination and request for information, and two potential conflict scenarios during and post-construction were simulated as part of the evaluation.	• Employing the prototype system, the design contributors could record their individual inputs to the overall project design and any critical file exchange transaction on a blockchain-powered system. • Records stored on the blockchain can help identify liable parties in times of conflicts and disputes. • The transactions recorded on such a system would be better purposed for audits and offer data integrity, authenticity, and longevity.
[39]	• The absence of a uniform and transparent system for managing quality information undermines the assurance process and may lead to disputes among stakeholders.	• Development of a blockchain-based framework for managing quality information – Product Organization Process (POP) quality Chain	• The proposed framework can decentralize the management of quality information, thereby achieving consistent and secure quality information management. • **Future research** in construction quality information management, blockchain technology has the potential of co-evolution with BIM and IoT technologies, which will further promote industrial cooperation and improve productivity.
[40]	• Effective contract administration could ease the achievement of project objectives as risk allocation, obligations, rights, and details of the required works are formulated in contracts	Examination of the administrative risks of smart contracts that limit the widespread use of their implementation via: • literature review • analytical hierarchy process (AHP) methodology	The top five risks challenging the adoption of smart contracts in construction projects are: • regulation change, • lack of a driving force, • works not accounted for in planning,

[1] Construction Contract Administration (CCA) is the process of ensuring each party's proper performance in meeting their contractual obligations.

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Ref.	Factors affecting project performance	Methodology	Important findings
	• a variety of disputes could occur due to misunderstanding of contract provisions in almost every project	• sensitivity analysis based on the degree of fuzziness and • focus group discussion (FGD) sessions with selected industry professionals to propose risk mitigation measures.	• shortcomings of current legal arrangements, and • lack of dispute resolution mechanism. Risk mitigation strategies based on FGD show that improvements for the semi-automated smart contract drafting are considered more practicable compared to full automation.
[41]	• Information interoperability management process in BIM-based construction projects	• Conceptual development of BIM-based contractual framework • Experts' review & exploratory case study	• Updated BIM content is vital for the progress of construction as it relates to maintaining, retrofitting, and demolition, i.e., the functions of model and data management of content during the maintenance phase. • **Future research** is needed to establish a reference framework drawing together the current and probably documented legal and contractual challenges for the BIM management process that will facilitate the seamless exchange and interoperability of information throughout the project life cycle.
[42]	• The progress payment administration process still relies on traditional payment applications that are time-consuming and open to potential disputes.	• Development of a BIM-integrated smart contract progress payment administration system for improving the traditional progress payment procedure for construction projects. • Application of proposed system to a real construction project and experts' views	• Accelerating the existing progress payment process by making preparation and approval of progress payments easier and less prone to disputes, especially for lump sum projects. • The proposed system enables partial automation of the progress payment process, requiring the involvement of the contractor and the employer. • **Future research** on a flexible smart contract architecture that enables the updating of unit prices could enhance the adoption of the BIM-integrated smart contract progress payment administration system for unit price projects.
[43]	• Poor knowledge of the key performance indicators (KPIs) hinders integrated BIM and integrated project delivery (IPD) adoption, which affects project timelines and budgets.	• Through a literature review and experts' opinions, a list of 24 KPIs was identified. • Factor comparison method and fuzzy decision-making trial and evaluation laboratory were utilized to prioritize the identified KPIs and disclose their interrelationships based on influential weight, respectively.	• 16 most critical key performance indicators (MCKPI) vital for BIM and IPD adoption in highly complex infrastructure projects were revealed. • 4 most influential and critical KPIs are: o accessibility and accuracy of information by BIM, o facilitating access to real-time data, o interoperability and compatibility of data, and o minimizing claims and disputes • more consideration should be given to the MCKPIs to enhance the project performance of

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Ref.	Factors affecting project performance	Methodology	Important findings
			complex infrastructure projects like metro rail construction.

4.4. Dispute resolution methods' assessment

As stated previously, whenever a claim arises by one of the parties involved and is rejected by the other, a dispute arises, a situation quite common in the construction industry [23,44]. According to El-Sayegh et al. [23], the two most common ways to mitigate disputes are avoidance and resolution. Dispute avoidance methods include negotiation, risk allocation, early non-binding neutral evaluation, and partnering, and they are used to prevent disputes from occurring. Resolution methods are further categorized into early (negotiation, conciliation, and mini-trial/executive tribunal) and late methods (negotiation, arbitration, mediation, adjudication, dispute review boards (DRB), and litigation). Early and late dispute resolution methods, except for litigation, are considered alternative dispute resolution methods (ADR). Initially, in the dispute resolution process, ADR methods are employed, and if these fail, the involved parties resolve to litigation and courts as a last resort [44].

Recent studies on dispute resolution methods, as illustrated in Table 7, apart from assessing [23] and selecting the most appropriate dispute resolution methods with regards to the causes of claims [45], also review novel ones such as online dispute resolution (ODR) methods, which fall under the category of ADR. ODR services are provided by several start-ups, established companies, and even higher-level authorities, such as the European Commission [1].

Table 7. Dispute resolution methods' assessment

Ref.	Project type/ Sector	Country	Dispute resolution method	Other findings
[23]	Construction sector, in general	United Arab Emirates (UAE)	**Dispute avoidance methods** *(ranked in order of their frequency in UAE)* • Negotiation • Risk allocation • Early Non-Binding Neutral Evaluation • Partnering **Early resolution methods** *(ranked in order of their frequency in UAE)* • Negotiation • Conciliation • Mini-Trial/Executive Tribunal **Late resolution methods** *(ranked in order of their frequency in UAE)* • Negotiation • Arbitration • Mediation • Litigation • Adjudication • Dispute Review Board	• The involvement of lawyers and the court is always the last resort and the least preferred option to solve a dispute.
[1]	Construction sector, in general	USA	**Alternative Dispute Resolution methods** • Negotiation • Mediation • Adjudication • **Online Dispute Resolution (ODR)**	• DCENTR's blockchain-based decentralized system facilitates on-time and direct payments, and JUS-DCENTR's justice-centering voting mechanism enables transparent, fast, and inexpensive dispute resolution. **Future research** on integrating an AI-based dispute assessment module into DCENTR for assessing potential disputes based on the information of past projects in addition to reducing and resolving them.

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Ref.	Project type/ Sector	Country	Dispute resolution method	Other findings
[45]	Road construction projects	Nepal	**Alternative Dispute Resolution methods** • Negotiation (most appropriate and preferred method) • Mediation • Adjudication	• Most disputes end up in arbitration • It is recommended to choose the ADR methods most appropriate to the causes of claims.

4.5. Claims/Dispute management process models

Claim management focuses on the identification, assessment and settlement of costs incurred over and above the amounts agreed upon in contracts due to additional work or damages [46]. This process is considered data-intensive and requires analysis of large amounts of diverse information, highlighting the importance of proper information and documentation management, which is essential in providing accurate data and proofs for claims, especially in the increasing complexity of architecture, engineering and construction (AEC) projects [47].

Recent studies attempt to address the problems observed in claim and dispute management by developing novel computer-aided claim management process models employing BIM [3,47] and Blockchain [48], as illustrated in Table 8. Fundamentally, claim management process models could either be utilized to provide data essential for proper and fast dispute resolution or to prevent even the occurrence of claims.

Table 8. Claims/Dispute management process models.

Ref.	Project phase	Process model	Important findings
[3]	Design	**BIM Tools/Functions** • 3D visualization • Coordination • Clash detection • Structure analysis • Collaboration • Quantity take-offs *(automatic extraction of the quantities contained in a BIM model)*	**Causes of claims addressed – stakeholder responsible** • Inaccurate quantities – Consultant • Excessive change order by owner – Owner • Design error or omissions – Consultant • Deficiency in drawing and specifications – Consultant • Poor communication and coordination between consulting engineers (structural, architectural, and MEP) – Consultant • Design change by the owner – Owner • Variations between original and actual quantities – Consultant • Design and specifications change – Consultant
[47]	Construction	**Main elements of BIM-based claim management expert system** • Inputs – technical/cost/performance/time data • Processing engine – checking the compliance of existing conditions with agreed conditions according to contract provisions *(contractual rules)* • Outputs – Report of contractual states of project & parties & Warnings before certain conditions occur	**Contributions to claim management** • Utilizing BIM to contain all project information and save time required to find, review & analyze paper documents. • BIM is easily updated by project progress, and the contractual rules can be controlled as the project evolves, notifying the responsible party before conditions that can lead to claims occur. **Limitation** • It is hard to provide a thorough BIM containing all the needed information from the beginning of the project using conventional delivery systems like Design Bid Build or Design-Build – Integrated Project Delivery (IPD), which provides the required platform for collaboration in a project.

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Ref.	Project phase	Process model	Important findings
[48]	Construction	**Blockchain-based system for Claim & Dispute support** • Application layer (user application) • Contract layer (Blockchain Extension Infrastructure) • Consensus layer • Network layer } network • Data layer (local) } Blockchain Basic Infrastructure	• The system can generate, transfer & synchronize blocks based on email communication whenever an event occurs. • System functions: o Document search o History tracking o Automatic extraction of related document o Authenticity verification for document management • Reliability of documents is secured during the recording, storing, and managing processes, supporting claim- and dispute-supporting tasks.

4.6. Methods for modelling and evaluating construction disputes

In this final subcategory, the most important findings of the recent publications regarding the methods for modelling and evaluating construction disputes are presented in Table 9. Recent studies have addressed the issue of modelling disputes either to predict the occurrence of disputes in construction [5,49,50] or to estimate the expected outcome of construction dispute resolutions, which can help professionals decide whether they should embark on dispute resolution or not [51,52]. Researchers also developed a methodology to model the disputes' causes and interrelationships to identify the significant causal factors responsible for triggering other causal factors and ultimately assist in reducing construction disputes [53].

Table 8. Methods for modelling and evaluating construction disputes

Ref.	Project phase	Methodology	Important findings
[53]	Construction	**4-step hybrid method to model disputes' causes and interrelationships** • Identification and Verification of Causal Factors (Literature Review) • Data Collection Using a Questionnaire Survey • Interpretive Structural Modeling (ISM) • Matrix Cross-reference Multiplication Applied to a Classification (MICMAC) Analysis	• 14 factors causing disputes • 6-level ISM hierarchical model of causal factors • 6-level ISM hierarchical model of causal factors: o 1st level (root cause) – Ambiguous language of contract document o 6th level (more damaging) – Cost overrun • MICMAC Analysis - interrelationships: o 6 dependent factors: weak drivers & strong dependents (i.e., Cost overrun) o 6 independent factors: strong drivers & weak dependents (i.e., Ambiguous language of contract document) o 2 autonomous (i.e., Technical incompetency of the stakeholders)
[5]	Pre-construction	**Hybrid fuzzy-Structural Equation Modeling (SEM) to quantify the probability of dispute occurrence** • List of main dispute categories and subcategories considering their occurrences during pre-construction • Development of a hybrid fuzzy logic-SEM model to evaluate the dispute occurrence likelihood	**Contributions** • Enabling early dispute resolution & prevention before construction • Targeting the proactive minimization or reduction of the rate of conflicts, disputes, and litigation occurrences

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Ref.	Project phase	Methodology	Important findings
[49]	Pre-construction	**Dispute prediction model by utilizing ML techniques on empirical data** • Development of a conceptual model to depict the common factors influencing dispute occurrence (Project characteristics/ Skills/ Changes/ Delays) • Development of prediction model (based on empirical data from past construction projects - questionnaire) • Finalization of prediction model via data classification – single and ensemble ML techniques	• 14 Factors with significant association with dispute occurrence: o 3 Project Characteristics-related: project location, value, planned duration o 9 Skills-related: i.e., communication between parties, relationship between parties/individuals, working culture and skills o **Changes** (the most influential factor) o Delays
[50]	Early stages	**ANN/decision tree–based model to assess the possibility of claim occurrence, given the project conditions (claim tenability)** • Identification of impact factors important for claim prediction (from literature & data from 8 real estate projects in India) • Variables coded using claim data, experts' interviews & project documentation *(input for the ANN-based model)* • Development of an ANN-based predictive model • Development of a decision tree model in Python using the same input data • Cross-model analysis to identify which factors affect claim occurrence • Combination of ANN and decision tree model to identify the most influencing factors for claim occurrence	• The feasibility & benefits of employing artificial intelligence/machine learning (AI/ML) techniques for predicting claims are demonstrated. • The developed artificial neural network (ANN)/decision tree-based model of claim tenability prediction identified "inconsistency between drawings and specification" as the most influencing factor. • Another critical factor is executing work based on verbal orders from the client without proper documentation. • Indication of the complex interactions among the factors leading to claims. • Risk mitigation & management mechanisms can be triggered to deal with the problematic factors identified by the developed model if/when these are found during the project.

5. Current research trends

The content analysis carried out in the previous subsection sheds light on the manner in which novel technologies such as BIM, Blockchain, Smart contract, AI, ML, NN or fuzzy logic and SEM have recently been employed in the research field of claim management and dispute resolution in the construction industry, explaining why these pose as current research trends in this research field.

To better comprehend these terms, it is helpful to present their definitions. Fuzzy logic refers to fuzzy set theory (FST), which is a branch of modern mathematics, and fuzzy technique methodologies can provide a viable tool for modelling subjective information and handling uncertainty where comprehensive data sets are not available for modelling [5]. The term smart contract was first introduced in 1994 by Szabo, describing it as "a computerized transaction protocol that executes the terms of a contract", suggesting the use of an automated protocol for satisfying contractual agreements, minimizing both malicious and unintentional errors, and eliminating the role of intermediaries in contract enforcement [54]. Structural equation modelling (SEM) is a class of multivariate techniques that combines the aspect of confirmatory factor analysis (CFA) in the form of a measurement model and regression or path analysis in the form of the structural model. SEM is one of the most useful advanced statistical analysis techniques that have emerged in the social sciences in recent decades, and the advantage of using SEM is that it can simultaneously examine the relationship between measured variables (independent variables) and constructs (dependent variables) [55]. Blockchain is the underlying distributed ledger technology (DLT) known primarily for underpinning the operation of the Bitcoin cryptocurrency network. A blockchain system can record transactions and validate digital events (e.g., information) conducted in the network in the form of encrypted "blocks" and can "chain" the entire recorded transactions chronology stored across

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multiple nodes. Blockchain operates on three core components: cryptography, consensus mechanisms, and decentralization [56]. Artificial Intelligence (AI), Machine Learning (ML) and Artificial Neural Networks (ANN) are AI technologies that can be employed, among other applications, in the construction industry to predict the occurrence of construction disputes or the outcome of construction litigation [2]. Building Information Modeling (BIM), as defined by the National Institute of Building [57], is "a digital representation of physical and functional characteristics of a facility… and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition". BIM can represent elements such as walls, doors, and windows as 3D objects and provide other information, including manufacturers, fire ratings, schedules and cost estimates attached to these objects. Furthermore, one important advantage of BIM is the ease of inserting, extracting, updating or modifying digital data by the stakeholders involved in the project (owners, clients, engineers, architects, contractors, suppliers and building officials) [47].

After gaining the necessary insight into what exactly these novel technologies represent, it is now more easily understood how these methods are employed for the scope of the research of this current paper. In Table 10, the publications, which were analyzed during the content analysis, employing these methods for addressing construction disputes are presented per project-phase research theme and causes of claims addressed in each article.

BIM, blockchain, and Smart contracts are usually combined to assist researchers and professionals in coping with the issues arising regarding claims and disputes in the construction industry, either by preventing or resolving them more efficiently when they occur. Additionally, since BIM has already had practical implications in construction for many years now and has proven how useful it has been, it can be more easily combined with emerging technologies such as Blockchain and Smart contracts, rendering this combination more readily accepted and proving its applicability in real construction projects.

Table 10. Novel technologies addressing claims in construction per project phase, research theme and causes of claims.

Ref.	Novel Technologies	Project phase	Research Theme (related content analysis section)	Causes of Claims (CCBS code from Figure 1)
[5]	Fuzzy Logic & SEM	Pre-construction	Methods for modelling and evaluating construction disputes (4.6)	-
[42]	Smart contract & BIM	Construction	Construction project performance (4.3)	Payment delays (A5)
[48]	Blockchain	Construction	Claims/Dispute management process models (4.5)	Inadequate Document management (D5)
[38]		Design/ Construction/ Post-construction	Construction project performance (4.3)	Change of scope (A1), Insufficient availability of information (C3)
[34]	Smart contract & blockchain	Procurement	The role of the human factor in construction conflicts (4.2)	Quality of works (B10)
[1]		Construction	Dispute resolution methods' assessment (4.4)	Payment delays (A5), Ambiguity in contract documents (D1)
[39]		Construction	Construction project performance (4.3)	Quality of works (B10)
[50]	AI/ML/NN	Construction (early stages)	Methods for modelling and evaluating construction disputes (4.6)	Inadequate/ incomplete specifications (C2), Lack of communication between CA and Contractor (E2)
[49]		Pre-construction	Methods for modelling and evaluating construction disputes (4.6)	Delays in work progress (B1), Change of scope (A1), Project characteristics (F1, F2)
[47]	BIM	Construction	Claims/Dispute management process models (4.5)	Insufficient availability of information (C3)
[3]		Design	Claims/Dispute management process models (4.5)	Design errors (C1), lack of communication between CA and Contractor (E2), Changes in quantities, work or scope (A1),

Ref.	Novel Technologies	Project phase	Research Theme (related content analysis section)	Causes of Claims (CCBS code from Figure 1)
				Inadequate/ incomplete specifications (C2)
[40]	Smart Contract	Life-cycle	Construction project performance (4.3)	Contract related (D1. D2, D3, D4, D5)

6. Conclusions

This paper explored the current state of research in the field of claim management and dispute resolution in the construction industry. This is a research area that has attracted extensive attention in the past 15 years. The bibliometric review conducted in this study through the VOSviewer software and the Scopus database recovered 791 documents published between 1983 and 2022, revealing that Australia, Hong Kong, and the United States of America are the countries contributing the most to this research field. Furthermore, the most influential scientific journals are "Journal of Legal Affairs and Dispute Resolution in Engineering and Construction", "Journal of Construction Engineering and Management" and "Construction Management and Economics", while Cheung S.O. along with Yiu T.W. and Fenn P. are the authors with the highest number of average citations. Conducting a co-occurrence author keywords analysis through VOSviewer, it was revealed that terms such as "blockchain", "smart contracts", "building information modelling (BIM)", and "claim management" appear only recently (after 2020) in the literature with regards to the construction claims and disputes research area. Attempting to shed light on the manner in which these concepts relate to construction claims and disputes, the recent documents published between 2020-2022 were further investigated, revealing six research themes: "Assessment of factors leading to claims/disputes (Section 4.1)", "The role of the human factor in construction conflicts (Section 4.2)", "Construction project performance (Section 4.3)", "Dispute resolution methods' assessment (Section 4.4)", "Claims/Dispute management process models (Section 4.2)", and "Methods for modelling and evaluating construction disputes (Section 4.6)", leading to a content analysis of 27 journal papers. Some of the most important findings and proposals for future research are presented per research theme.

Regarding the assessment of factors leading to claims and disputes related to modular construction projects [28], where construction disputes are triggered mainly by the occurrence of multiple causes rather than by just a single cause, future research could focus on the necessary, appropriate adjustments of the contractual aspects of modularization in construction. Furthermore, when examining the role of the human factor in construction conflicts, unethical practices of bid shopping and peddling during the subcontractor (Sub) procurement process can negatively affect construction conflicts. The blockchain-based framework proposed by Pishdad-Bozorgi and Yoon [34] can prevent these unethical practices and enable Subs to fairly compete for bid awards with proper budgets, enhancing the trust between the general contractor and Subs. As far as the construction project performance is concerned, the absence of a uniform and transparent system for managing quality information was found by Sheng et al. [39] to undermine the assurance process, which can lead to disputes among stakeholders. Future research in construction quality information management is proposed by highlighting that blockchain technology has the potential to co-evolution with BIM and IoT technologies, which could further promote industrial cooperation and improve productivity.

Moreover, when assessing the methods employed for resolving disputes, it was found that ADR methods are preferred over litigation and future research on integrating AI and blockchain is proposed so that potential disputes can be assessed based on the information of past projects in addition to reducing and resolving them [1]. BIM and blockchain were also found to enhance claim management during the design and construction phase of a project, which resulted in developing process models that could either be utilized to provide data essential for proper and fast dispute resolution or to prevent even the occurrence of claims. It is also proposed that Integrated Project Delivery (IPD) should be used as the project delivery system, since it provides the required platform for the necessary collaboration in a project [47]. Finally, regarding the research on the methods for

modelling and evaluating disputes, some important findings were that there are complex interactions among the factors leading to claims and that "inconsistency between drawings and specification" was considered the most influential factor leading to claims, according to the developed artificial neural network (ANN)/decision tree-based model of claim tenability prediction [50].

The most important contribution of this perspective paper is that the content analysis revealed the current research trends using novel technologies such as BIM, blockchain, smart contracts, AI, ML, NN fuzzy logic and SEM. AI, ML, NN and, fuzzy logic & SEM are mainly employed during the pre-construction phase of a project or at the early stages of construction to model and evaluate construction disputes. The causes of claims addressed in these research endeavours include Change of scope (A1), Delays in work progress (B1), Inadequate/ incomplete specifications (C2), lack of communication between CA and Contractor (E2), or Project characteristics (F1, F2). In some cases, BIM, Blockchain and Smart contracts, either individually or combined, have been applied during the design, construction or post-construction phase of a project to address the construction disputes related to Change of scope (A1), Payment delays (A5), Quality of works (B10), Design errors (C1), Inadequate/ incomplete specifications (C2), Insufficient availability of information (C3), Ambiguity in contract documents (D1), Inadequate Document management (D5), or lack of communication between CA and Contractor (E2). Nevertheless, the literature revealed that there are still issues and limitations of these novel technologies to be addressed when it comes to applying them in actual construction projects, mainly due to the different levels of familiarity the parties involved in construction possess with these methods.

Furthermore, a research gap was observed regarding the combination of BIM, Blockchain and Smart contract applications in road projects. This could indicate a potential future research direction as to how and if this "partnership" can be employed for addressing disputes arising in road projects. Another direction for future research could be to explore the level of familiarity public road contracting authorities have with BIM, Blockchain and Smart contract applications in general and on specific project types. For example, road projects, as only three out of the 27 articles analyzed focused on this project type (in Sri Lanka [21], India [22], and Nepal [45]). To this end, attempting to facilitate the public sector into entering the era of Industry 4.0 in construction, future research could focus on developing a road map for the application of smart contracts for Road construction, operation, and maintenance to be tailored to the contracting road authorities' needs.

Finally, although this study covered an extensive range of representative papers to reflect the status of claim management and dispute resolution in the AEC industry in its entirety, limitations exist due to the employment of the Scopus database and the VOSviewer software. Similar research could be conducted employing the CiteSpace software and the Web of Science database in an attempt to reveal more exciting findings with regard to bibliometrics since CiteSpace offers more possibilities in this field.

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