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Perspective

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

Marianna Kalogeraki and Fani Antoniou *

Department of Environmental Engineering, International Hellenic University, 57400 Sindos, Greece; dcie20210001@cie.ihu.gr
* Correspondence: fanton@ihu.gr

Abstract: In the Architecture, Engineering and Construction (AEC) industry claims arise frequently, often resulting in disputes. Claim management should be efficient to prevent claims from escalating into disputes, and if disputes are still unavoidable, they should be resolved without delay for the construction process to resume. First, by conducting a bibliometric review, this paper attempts to investigate the literature on construction claims and dispute resolution practices by employing the Scopus database and VOSviewer to retrieve and analyze related sources. The overall trend of research by country, source, and authors is detected, and the emergence of novel technologies such as BIM, blockchain, and smart contracts appearing after 2020 concerning the investigation into construction claim management and dispute resolution was identified. Second, a content analysis on the most recent publications published between 2020 and 2022 was undertaken, indicating six main research themes that represent current research trends. The employment of novel technologies to enhance claim management and dispute resolution practices in the AEC sector is identified, as well. Finally, in order to assist construction professionals and researchers in their work to address construction claims and disputes more efficiently, potential research directions are proposed.

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

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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 is not any different in the construction industry, where an extremely complex and multi-dimensional 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 during the procurement 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. Hence, claim submission and rejection 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 that could be spent more productively [2], can lead to cost and time overruns [1–3,6,8], and can also generate problems in the involving parties'

working relations, which could even cause these relationships 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 contract, the design, the contractor, human behavior, external factors, and the project. Figure 1 presents a risk breakdown structure of 39 causes of claims (risk factors) by providing a thorough perspective on the hierarchy of the leading causes of claims based on Cakmak and Cakmak's classification, as 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".

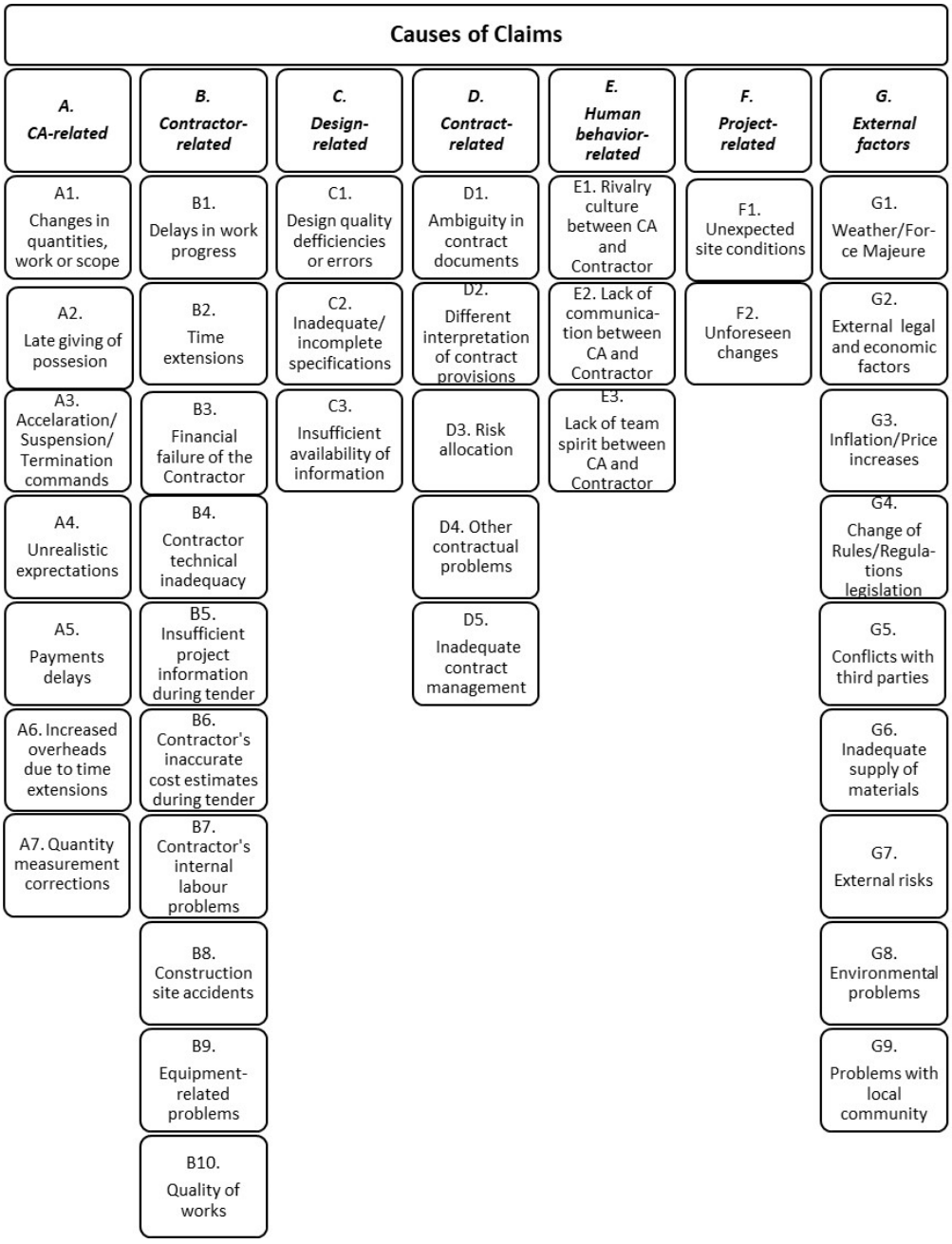

Figure 1. Causes of claims breakdown structure (CCBS) [10].

This highlights the crucial role of contracts in the claim management and dispute resolution processes, deeming that a thorough understanding of the contract during the pre-design phase of a project is essential. During the design phase, the proper form of project delivery and the most suitable contract type should be appropriately selected and included in the draft contract by considering the project's and contracting authority's needs, the proper standard contract language and the provisions for addressing the dispute resolution process. Standard contract language and dispute resolution-related provisions can be found in standard forms of contract, such as the ones published by the International Federation for Consulting Engineers (FIDIC) or the ones found in the New Engineering Contract (NEC) [11]. Choi and Kim [12] underline that the roles, rights and responsibilities of construction parties are clearly defined in the FIDIC contract provisions. Additionally, the risks between the employer and the contractor are reasonably distributed depending on the contract type, resulting in various standard forms of FIDIC contracts. For example, the FIDIC Red Book contains contractual provisions and standard terms for the construction contracts tendered following the traditional project procurement system (PPS) of a design–bid–build contract. Similarly, the FIDIC Silver Book provides the same for the build–operate–transfer (BOT)/turnkey PPS and the Yellow Book for the design–and–build PPS. According to the 2021 ARCADIS report, employing standard forms of contracts, such as FIDIC, will enable timely notification, early warnings, and claims substantiation, allowing the involved parties to reach concurrent interim agreements and preventing the crystallization of disputes. Also, in the same report, it is highlighted that the inability of the contractual parties to comprehend and/or comply with their contractual obligations, along with the issue of poor claims documentation, are considered the two main reasons for construction disputes [1].

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 mediation, negotiation, arbitration, litigation, or any alternative dispute resolution method (ADR) [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 [8].

This perspective paper aims to inquire into the current research trends regarding claim management and dispute resolution in the AEC sector, identify any research gaps and provide suggestions for future research directions in order to assist construction professionals and researchers in their attempts to handle more efficiently construction disputes and their negative impacts on project performance.

Following this introductory section, Section 2 contains an overview of the methodology used to conduct this research, which is similar to the one the same research team followed when investigating the current research trends into the way climate change affects the built environment [13]. It also presents the initial keyword search and the annual distribution of the documents found to undergo science mapping. Section 3 presents the overall trend of research by country, source, and authors. Furthermore, the results of the co-occurrence keyword analysis are presented identifying the emergence of novel technologies such as BIM, blockchain and smart contracts related to the investigation into claim management and dispute resolution in the AEC sector. Subsequently, a content analysis of the papers published in 2020–2022 is carried out in Section 4, indicating six main research themes, which pose as the current research trends for the scope of this research. These six research trends and the identified employment of novel technologies for enhancing construction claim management and dispute resolution are discussed in Section 5. In Section 6, the conclusions of this paper are presented, highlighting the most important findings of this research, identifying research gaps, and providing suggestions for future research.

2. Methodology

Science mapping techniques, including bibliometric analysis, informatics, and scientometrics, are used to visualize the state-of-the-art in scientific research regarding construction claims and dispute resolution practices used in construction. While bibliometric analysis concentrates on the literature, it is scientometrics that measures and analyzes the literature data and informatics that allows the visualization of the results to help describe the scholarly structure of a scientific area and the practices used by scientists [14,15]. The characteristics such as country, source, and author of construction claims and dispute resolution Scopus-published articles were examined based on bibliographic coupling and citation analysis. Following a keyword co-occurrence analysis, the emerging research topics, their temporal trends, and the gap in research were detected. Finally, the authors performed a manual content analysis of the recently published studies related to this research field to deepen the analysis and classify trends in scientific research of claim and dispute resolution methods in construction.

Science mapping and visualization tools (e.g., VOSviewer, CiteSpace, VantagePoint, CoPalRed, BibExcel, Sci2, and Gephi) [14] are employed to analyze data retrieved from scientific literature databases, (e.g., Scopus, Web of Science), and present them with visual features. For this quantitative analysis, VOSviewer was selected, as it is one of the most recommended tools and also possesses special features concerning text-mining [15]. In addition, it was necessary to utilize OpenRefine (version 3.5) software to improve the data obtained from Scopus along with a thesaurus file to correct keyword spelling errors and typos and to merge similar terms to facilitate better keyword co-occurrence results.

The Scopus (Elsevier) database was selected for the document search as it is one of the most comprehensive ones, includes a greater number and broader range of indexed publications in the engineering discipline and is more user-friendly [16] in comparison to that of the Web of Science. Also, in contrast to the Google Scholar database, it is not prone to double-citation-counting problems. To collect the data, the following statement was entered in the Advanced Search prompt: TITLE-ABS-KEY (disput*) OR TITLE-ABS-KEY (“construction claim*”) AND ALL (“construction management”). The wildcard “*” was used to capture term variation [17]. The selection of keywords was made with respect to the purpose of this research, meaning to explore which aspects of claim management and dispute resolution in the AEC sector are currently being investigated by the researchers. The keyword “construction claim*” was selected over plain “claim*” to prevent retrieving articles where the word “claim” was used as a verb and was not relevant to the scope of this research. A filter was applied to include English articles published in scientific journals or conference proceedings. Conference papers were included in the initial screening process, along with journal papers, in order not only to obtain a more comprehensive database of papers [15,17] but also to indicate the researchers’ possibly evolving interest. Finally, this approach resulted in retrieving 791 documents, out of which 543 were journal articles (69%) and 248 were conference papers (31%), published from 1983 to 2022 (retrieved online on 22 November 2022).

Figure 2 shows that the number of publications published per year has been rising consistently from 1983 to 2022. It also indicates that the number of annual publications started increasing exponentially after 2007 and almost 43% of all the relevant documents have been published in the past five years. In total, the 791 publications have been cited 9762 times, giving a mean of 12 citations per paper. The steep rise in published articles over the past fifteen years demonstrates that construction claim management and dispute resolution research continues to attract extensive attention, illustrating the importance of the impact claims possess in this domain.

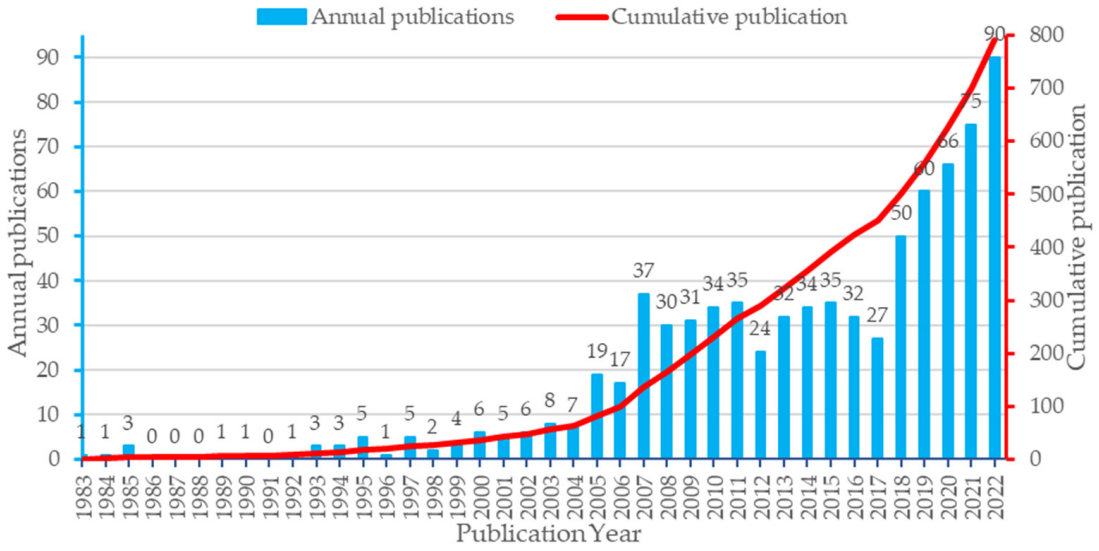

Figure 2. Distribution of the indexed research published in 1983–2022 (Scopus, 22 November 2022).

Following the bibliometric analysis that was essential for the determination of the proposed future research directions, a content analysis of 27 research articles published in the past three years was conducted. 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 [18], as described in detail in Section 4.

3. Bibliometric Analysis

In order to proceed to analysis using VOSviewer (version 1.6.18), the Scopus document data was downloaded to a .csv file. VOSviewer is a free software tool employed to generate maps based on network data, bibliographic data or text data obtained from the titles and abstracts of documents [19]. Bibliographic database files (e.g., Scopus, Web of Science, PubMed, Lens, and Dimensions files), reference manager data (e.g., EndNote, RIS, and RefWorks data), as well as data downloaded through an application programming interface (API), can be provided as input to VOSviewer. The selection of the appropriate data type among these three is performed in the first step of the Create Map wizard. VOSviewer can produce three types of visualization maps, namely network, overlay, and density, also offering the functionalities of zooming and scrolling, providing the user with the possibility to explore the map in full detail, which is necessary when exploring large maps containing thousands of items. The main window of VOSviewer consists of five panels, the main (showing the currently active map), the options (for adapting the visualization in the main panel), the information (providing descriptions of the items presented in the main panel), the overview (overview of the currently active map), and the action panel (for performing actions such as generating a new map, capturing a screenshot, opening a saved map or saving another, and updating the clustering or layout of one). The techniques used in VOSviewer are normalization, mapping, and clustering. Since in a bibliometric network, substantial deviations among nodes regarding the quantity of links they have to other nodes are often observed, and normalization for these differences is usually performed when analyzing such networks, VOSviewer by default applies the association strength normalization. Afterwards, the nodes are positioned in the network in a two-dimensional visualization where strongly related nodes can be seen close to each other while weakly related ones are located further away. This procedure lies in the Visualization of Similarities (VOS) mapping technique performed by the software. The software by default assigns the nodes in a network to clusters, meaning sets of closely related nodes, and each node can be assigned to exactly one cluster. The nodes assigned to a cluster are shown in the same color. A resolution parameter defines the number of clusters and the higher the value of this parameter, the more the clusters. This clustering procedure is essentially an optimization

problem, requiring an algorithm for its solution, which in the VOSviewer environment is the smart local moving algorithm. Further details on these three techniques can be found in the book chapter titled "Visualizing Bibliometric Networks" [20].

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. In such a map, only one type of link is typically included. Any pair of items can be connected with only one link, which has a strength described by a positive number. The higher this number, the stronger the link. For instance, in the case of co-occurrence links between two terms, the strength of the link shows in how many publications two terms appear together. Items and their links form a network. Items can have weight and score attributes, which are assigned numerical values. Two standard weight attributes, i.e., Links and Total Link Strength indicate the importance of an item. The Links attribute shows "the number of links of an item with other items", whereas the Total Link Strength (TLS) indicates "the total strength of the links of an item with other items" for the whole network. It should be noted that in VOSviewer, weight attributes are considered to have a ratio scale, meaning that if an item is characterized by a weight two times higher than the weight of another item, the former item is twice as important as the latter item. Presenting the abovementioned basic terms is essential to understanding the following results produced via the VOSviewer software [19].

3.1. Country Analysis

All construction projects are prone to conflict [21]. The reasons for the claims occurring due to such conflicts, as well as the means of resolving these disputes, are researched throughout the world. Bibliographing coupling was selected to find the countries that contribute most to research in this field. Hence the pertinence of countries is determined according to how many references they share [19], setting the limit to at least five documents per country. Out of the 65 countries that have published at least one relevant study, 31 met the five-document threshold. The number of documents and citations, the average number of citations per document as well as the TLS of the five most prominent countries, Australia, Hong Kong, the USA, the UK, and China, are illustrated in Table 1. At the same time, all 31 of them are shown in Figure 3, visualized in five groups (clusters).

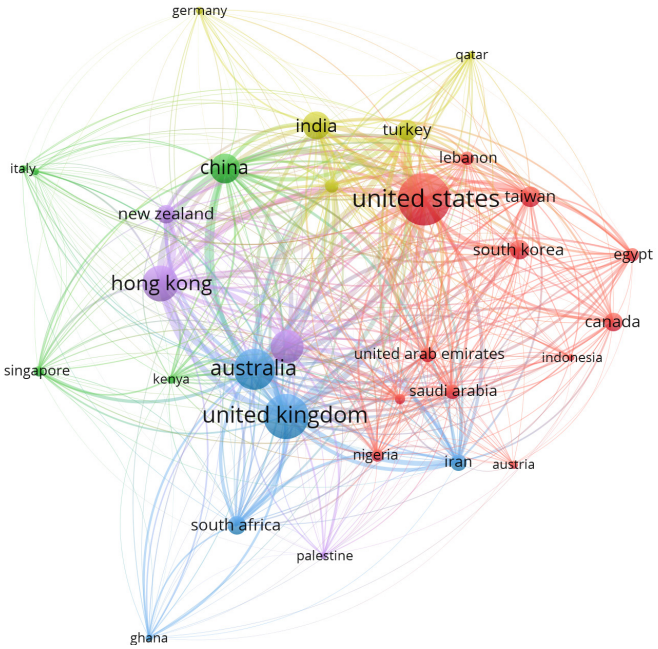

Figure 3. Most influential countries in 1983–2022.

Table 1. Citation and document data concerning the five most influential countries.

ID	Country	Documents	Citations	Avg. Citations	TLS
1	Australia	90	1294	14	12896
2	Hong Kong	74	2322	31	11374
3	USA	137	2102	15	10663
4	UK	107	1374	13	10634
5	China	54	1032	19	8797

3.2. Publication Sources Analysis

According to the citation analysis, 218 journals and conference proceedings published 791 papers, and the frequency by which these publication sources cite one another determines their pertinence [19]. A total of 106 sources met the threshold of more than five publications. The top five sources by TLS, which presents the total strength of the links of the sources with other sources, are shown in Table 2, along with citation and document data of each source, such as the number of published documents, number of citations, TLS, and the journal's Scopus quartile (SQ), based on the 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* contributed the most to this research area according to their TLSs.

Table 2. Top five publication sources according to their TLSs.

ID	Journals	Documents	Citations	TLS	SQ
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

It was found that 1512 authors published at least one related paper. To pinpoint those researchers who have contributed the most, a citation analysis using VOSviewer and using "Authors" for the analysis unit was conducted. In other words, the relatedness between authors is decided by how often they cite each other. In this case, authors that had published a minimum of five papers and were cited at least five times were counted. These restrictions resulted in the detection of 38 authors. Of these, 37 were connected to at least one other researcher (Figure 4).

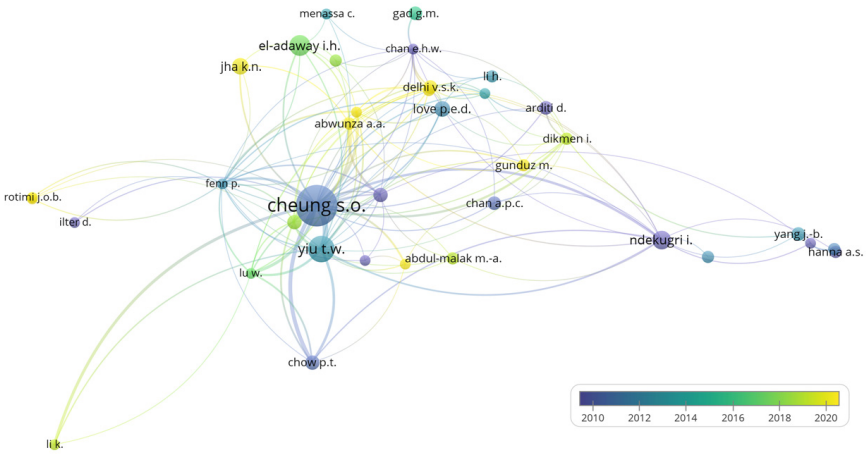

Figure 4. Magnitudes of the publications per author by average publication year.

VOSviewer software allows the color-coding of the authors' network classified by date of publication (year). As shown in Figure 5, the authors shown in yellow are those with the most recent publications (i.e., Gunduz M. and Abwunza A.A.). On the other hand, the green-, blue-, and purple-type authors provided earlier contributions to the literature (i.e., Cheung, S.O.; Love, P.E.D.; and El-Adaway, I.H.). Table 3 presents the top five authors according to TLS, where it can be observed that Cheung, S.O., is the author of most of the documents related to the examined field (45), and Yiu, T.W., and Fenn, P., were the most cited authors.

Table 3. Top five authors.

ID	Author	Documents	Citations	Avg. Citations	TLS
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)

The co-occurrence network of author keywords option in VOSviewer was employed for the keyword analysis. In this case, how strongly the keywords are related to each other is determined based on the number of published documents in which they appear together [19]. A related keywords map allows researchers to create a solid depiction of the state-of-the-art by examining the sequences, relations, and intellectual organization of themes studied [14]. To create the network, the minimum number of keyword occurrences was set to 10, after additional data processing using OpenRefine and a specially produced thesaurus file, which was necessary to merge similar terms and to correct spelling and typo errors.

The resulting network is made up of 52 nodes (keywords) and 583 links, is grouped into 5 clusters, and is depicted in two forms in Figures 5 and 6. Figure 6 represents a density visualization map, where the point size depends on the document density number at that point. The keywords corresponding to different clusters are displayed in varying colors, thus reflecting interrelations between research areas [22,23]. The keywords "construction disputes and conflicts" and "claims and disputes" are, as was expected, the most repeated ones, interconnecting all five clusters. The first (red) cluster revealed 16 keywords (in descending order of occurrence): construction, risk management, partnering, contractors, procurement, performance assessment, building sector, collaboration, public construction project, subcontracting, causal analysis, factor analysis, organizational culture, cooperation, defects, and quality management. In the second (green) cluster, the following 11 keywords were clustered and reported in descending order of occurrence: construction disputes and conflicts, project management, construction projects, fuzzy logic, dispute management, claim management, causes of claims and disputes, public–private partnership (PPP), case study, stakeholders, and decision making. Accordingly, in the third (blue) cluster, the following ten keywords were clustered: dispute resolution, construction management, alternative dispute resolution (ADR), arbitration, litigation, negotiation, mediation, adjudication, legal issues, and international construction. In the fourth (yellow) cluster, the following eight keywords were grouped: construction contracts, building information modeling (BIM), design management, information management, blockchain, document management, modeling, and smart contracts. Finally, in the fifth (purple) cluster, the following seven keywords were reported: claims and disputes, delay, cost analysis, scheduling, time, change orders, and productivity. Considering that the data visualized in Figure 5 is classified by average publication year, meaning the nodes in yellow are the ones appearing more recently in the literature, it was observed that the nodes of the fourth cluster (showed in yellow in Figure 6), including "building information modeling (BIM)", "blockchain", "smart contracts", and others, appear in the past three years in the literature with regard to construction claims and the disputes research area, along with the green (Figure 6) cluster's node "claim management". Attempting to shed light on the manner in which novel technologies, such as the ones above, relate to construction

claims and disputes, the recent documents published during the last three years were further investigated by carrying out the content analysis as described in the next section.

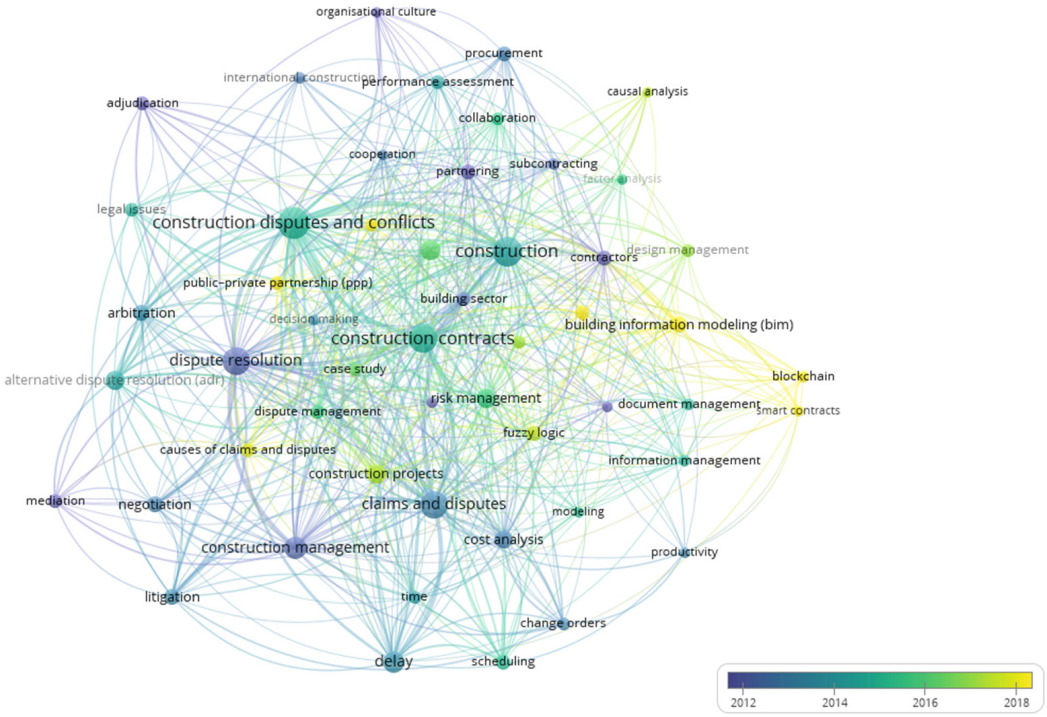

Figure 5. Main keywords repeated in documents by average publication year.

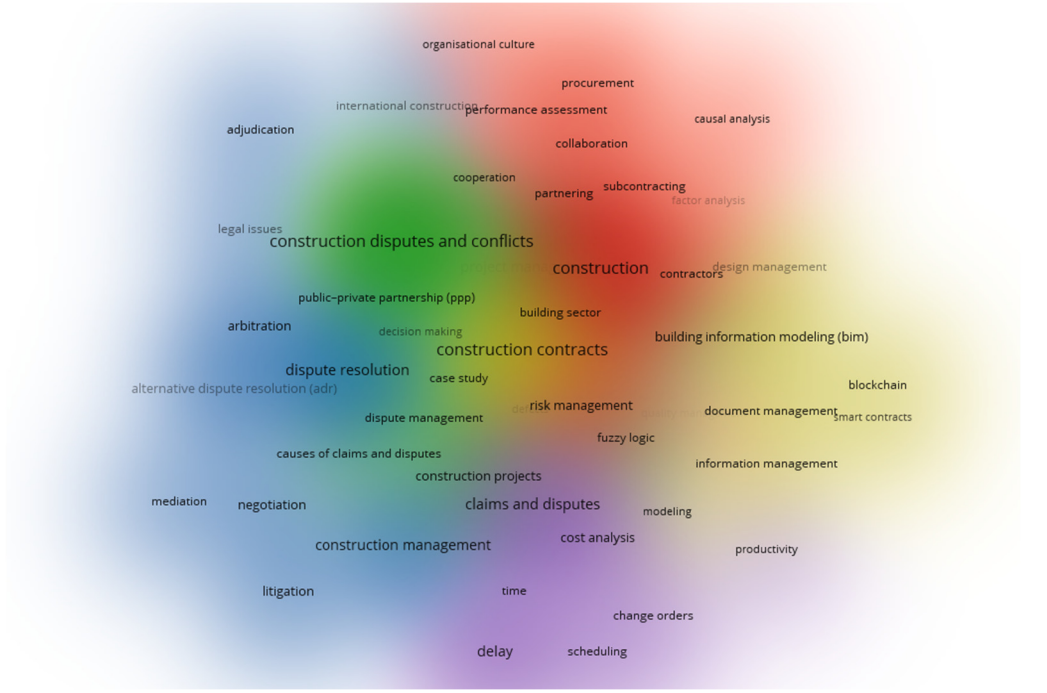

Figure 6. Main keywords repeated in documents grouped in five clusters.

4. Content Analysis of the Most Recent Publications

As stated before, the PRISMA method was followed for selecting the studies for content analysis. The PRISMA statement consists of an items' checklist to include when recording a systematic review or meta-analysis and a flow diagram of four stages, with

the purpose of aiding authors in enhancing the recording of systematic reviews and meta-analyses. Although PRISMA and its predecessor QUOROM (QUality Of Reporting Of Meta-analyses) were first developed for the medicine research area, the general concepts of PRISMA can be applied to any systematic review, along with the appropriate modifications of the items' checklist and/or flow diagram [18]. Figure 7 shows the adapted PRISMA flowchart for the identification, screening, eligibility, and inclusion stages of the process that was used for the ultimate selection of the best studies to undergo content analysis.

As was revealed in Figure 2, a significant amount (341 documents) of the related literature was published during the last five years, indicating the growth of researchers' interest in this research field. Additionally, since the purpose of this paper is to explore the current research trends in claim management and dispute resolution in the construction industry, a manual content analysis of the 231 journal articles' and conference papers' titles and abstracts published during the 2020–2022 period was performed, resulting in six themes/trends, as listed below, including the number of corresponding studies as well.

1. Assessment of factors leading to claims/disputes (79 studies);
2. The role of the human factor in construction conflicts (19 studies);
3. Construction project performance (53 studies);
4. Dispute resolution methods' assessment (25 studies);
5. Claims/dispute management process models (37 studies);
6. Methods for modeling and evaluating construction disputes (18 studies).

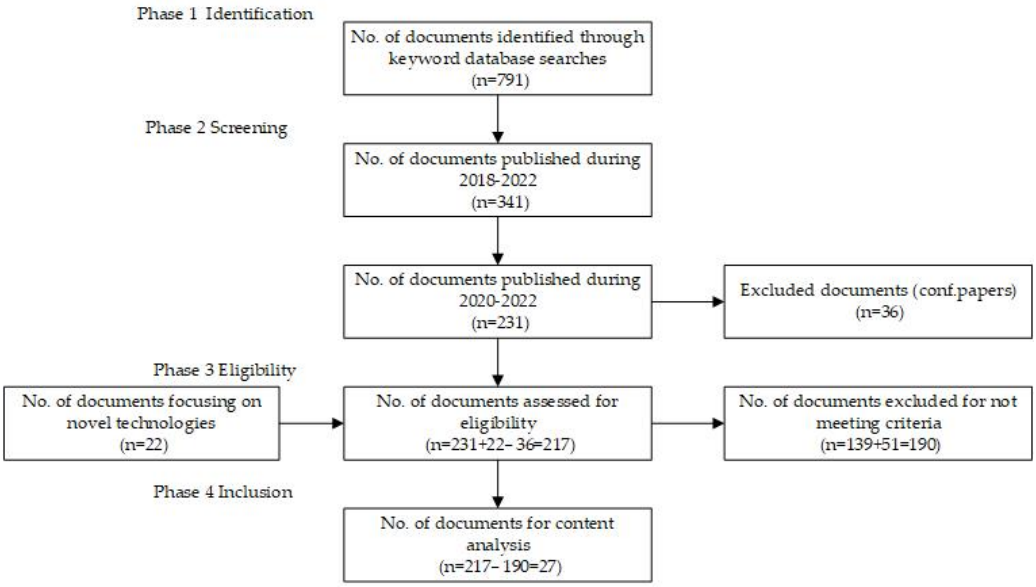

Figure 7. PRISMA flowchart for selection of documents.

To better comprehend the current research trends, 27 out of these 231 publications were further shortlisted to undergo a manual full text content analysis, based on the following criteria taking into account the citation patterns revealed in the scientometric analysis presented in Section 3.

- 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 five 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 [24]. The second inclusion criterion was chosen to investigate how these recently emerged terms are associated with construction claims and disputes, as was revealed in Section 3.4. The third exclusion criterion was applied following the publication and citation patterns and thresholds selected during the bibliometric analysis conducted in Section 3. In this step of the selection process, the threshold of five 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 best articles based on the results of Sections 3.2 and 3.3. Some of the most important findings of these 27 selected publications are presented by 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 (e.g., road projects [25,26]) or on the construction sector in general [27], as well as investigating either all types of causes [27–29] or a particular type (e.g., variations [25,30]).

It is also noteworthy that five of the seven studies presented in Table 4 focus on identifying lists of claim/dispute causes [26–28,30,31], and in the other two, the emphasis is 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 [25,29]. Further details to better comprehend these two different research approaches regarding factors leading to construction claims can be found in Table 4 as follows.

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

Ref.	Project Type/Sector	Country	Causes of Claims/Disputes	Findings
[27]	Construction sector, in general	UAE	1. Contracting authority (CA) changes; 2. Obtaining permit/approval from governmental authorities; 3. Material changes; 4. CA's slow 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.
[28]	Residential/commercial buildings—**highest % among all other types,** i.e., water and sewer lines, roads and highways, power plants, hospitals, and airports.	UAE	1. Change/variation in orders; 2. Delay caused by the owner; 3. Changes in material and labor 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 concept to share risk between owner and contractor. • Using the ADR method to resolve claims before going to litigation.
[30]	Building construction projects (lump sum and DBB)	North Cyprus Turkey USA	**Change** factors—Categories 1. Planning and design (e.g., inconsistencies between different designs). 2. Construction and site (e.g., additions/omissions of work items). 3. Human factors (e.g., lack of experience of project participants). 4. Administrative (e.g., low contract price/competitive bidding). 5. External (e.g., shortening/compression of project schedule).	• Contractors', consultants', and owners' views vary according to the different countries/regions. • Suggestions to reduce the need change-related disputes: finer preparation of project documents and thorough organization before construction begins.

Table 4. *Cont.*

Ref.	Project Type/Sector	Country	Causes of Claims/Disputes	Findings
[25]	Road projects	Sri Lanka	**Root** causes of **variations** 1. Ambiguity in contract documents. 2. Unexpected site conditions. 3. Changes in quantities, work, or scope due to design changes. 4. Quality of works. 5. Poor procurement process. 6. Unavailability of equipment. **Proximate** causes of **variation**-related disputes 1. Quantity measurement disputes. 2. Disagreement on the scope of omission. 3. Delay by CA to order variations. 4. Disputes on the new rates. 5. Different interpretation of contract provisions.	**Suggestions** to reduce/manage potential variation-related disputes • Emphasis on scope planning and documentation. • Behavioral evaluation of team. • Thorough evaluation of site conditions by both CA and contractor. • Fully defined scope. • Design reviews and audits.
[29]	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.
[31]	n/a	n/a	**Contract Readability risks** 1. Unnecessary complexity in using nouns. 2. Using abstract and vague clauses or terms leads to various interpretations. 3. Needless long sentences used.	• Improved readability could reduce conflicts, claims, and disputes in construction.
[26]	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** • Ensure project-specific contract provisions. • Strict enforcement of contract provisions and compliance by both the CA and contractor.

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 with different roles and perceptions regarding the project must work together [1–3]. As a result, it is not unusual to see both parties failing to benefit from obvious win–win options [32–34]. Additionally, as engineering professionals are involved in managing conflicts arising under construction contracts, it is vital to understand the spectrum of the increased claim administration roles that engineers are called to exercise, and the necessary traits, practices, and requirements that are observed when these roles are fulfilled [35].

In the current subsection, recent studies attempting to explore in detail how the human factor affects construction conflicts are examined. Table 5 presents the 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 [36], during other stages of the project lifecycle as far as building construction

projects are concerned (design, construction, services installation, maintenance) [37], or at the early stages of the claim evolution process [35].

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

Ref.	Project Type/Sector	Project Phase	Human Factors Affecting Construction Conflicts	Findings
[36]	Construction sector generally	Procurement	Unethical practices of bid shopping and trading in the Sub procurement process.	• Development of a blockchain-enabled smart contract system to establish that the subcontracting procurement process is based on trust. • Unethical practices are prevented by the proposed framework enabling subcontractors to participate in fair competitions for bid awards with appropriate budgets. • Enhancement of trust between subcontractors and the general contractor via the proposed framework.
[37]	Building construction projects	Design, construction, services installations, maintenance	Practices of RD, a cause of disputants' irrational decisions which affect CDN.	RD behaviors in CDN: • Biased information processing; • Hesitancy to change; • Overconfidence; • Doubts about counterpart's skills; • Distrust toward the counterpart.
[35]	Construction sector generally—through the 2017 FIDIC contract conditions' scope	Early stage of the claim evolution process	**Identified Engineer's traits** 1. Objectivity; 2. Due diligence; 3. Standard of care; 4. Impartiality; 5. Professionalism.	• The engineer's decision-making and consultive roles imitate those undertaken by arbitrators and mediators, respectively. • The contract engineer ought to act impartially and be prepared to act as a mediator when performing the consultative role and as an arbitrator when reaching a fair outcome.
[38]	Construction sector generally	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. 2. Decision outcome considering the following variables (through engineering ethics' scope): **a. Fairness;** b. Outcome favorability (found to be not significant); **c. Procedural fairness;** **d. Quality of treatment experienced;** e. Quality of the decision-making process (found to be not significant); **f. Control.**	• By investigating stakeholders' perceived fairness, their nature to cooperate is also examined. • Highlighting perceived fairness to the contractor's behavior. • 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. Effects on 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 a project's performance success or failure. Hence, it is imperative to determine causes of claims and to mitigate

them efficiently as well as to improve the project performance so that the projects can be completed in the scheduled cost and time [7,27]. In fact, this research team has recently completed research that pioneers by simultaneously examining experts' views on the frequency of occurrence of causes related to contractual claims and their perceived effect on the final project's time, total cost, and quality [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, which could result in claims and, ultimately, disputes.

Table 6. Effects on construction project performance.

Ref.	Factors Affecting Project Performance	Methodology	Findings
[39]	• CCA (construction contract administration—the process of ensuring each party's proper performance in meeting their contractual obligations.)	• Developing a fuzzy structural equation model to measure 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 identified indicators contribute significantly to the overall CCA performance, and no single item can be ignored.
[40]	• 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 the 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 after construction were used in a simulation as part of the evaluation.	• By employing the prototype system, the design contributors could record their distinct contributions to the general 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.
[41]	• The absence of a consistent and clear 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—POP quality chain.	• The proposed framework can decentralize the management of quality information, resulting in attaining constant and secure quality information management. • **Future research** in construction quality information management, where blockchain technology could co-evolve with BIM and IoT technologies, to promote industrial cooperation and improve productivity.

Table 6. *Cont.*

Ref.	Factors Affecting Project Performance	Methodology	Findings
[42]	• Effective contract administration could ease the achievement of project objectives as risk allocation, obligations, rights, and details of the required work are formulated in contracts. • A variety of disputes could occur due to the misunderstanding of contract provisions in almost every project.	The examination of the administrative risks of smart contracts that hinder the widespread use of their implementation via: • Literature reviews; • AHP methodology; • Sensitivity analysis based on the degree of fuzziness; • FGD sessions with selected industry professionals to propose risk mitigation measures.	Top five challenges to the adoption of smart contracts in construction projects: • regulation change, • Missing a driving force; • Unaccounted works during planning; • Limitations of current legal arrangements; • Missing dispute resolution mechanisms. • The proposed risk mitigation strategies show that semi-automated smart contract drafting improvements are viewed more realistically in contrast to full automation.
[43]	• Information interoperability management process in BIM-based construction projects.	• Conceptual development of a BIM-based contractual framework. • Experts' review and exploratory case study.	• The critical role of updated BIM content in the construction progress during the maintenance phase, associated with maintaining, retrofitting, and demolition. • **Future research** is needed to establish a reference framework considering existing and possible contractual challenges for the BIM management process, to enable information exchange and interoperability during the project life cycle.
[44]	• The progress payment administration process still relies on traditional payment applications, which are grinding and susceptible 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.	• The current progress payment procedure is accelerated by making progress payment preparation and approval easier and less susceptible to disputes, particularly for lump sum projects. • The proposed system enables the partial automation of the progress payment procedure, requiring the involvement of the contractor and the employer. • **Future research** on a flexible smart contract framework enabling the updating of unit prices could facilitate the adoption of the proposed progress payment administration system for such projects.

Table 6. *Cont.*

Ref.	Factors Affecting Project Performance	Methodology	Findings
[45]	• Poor knowledge of the KPIs hinders integrated BIM and 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 trials and evaluation were utilized to prioritize the identified KPIs and disclose their interrelationships based on influential weight, respectively.	• The 16 most MCKPIs vital for BIM and IPD adoption in challenging infrastructure projects were revealed. • The 4 most influential and critical KPIs are: ○ Accessibility and accuracy of information by BIM; ○ Providing access to real-time data; ○ Data interoperability and compatibility; ○ Reducing claims and disputes; • Focusing more on the MCKPIs for enhancing the project performance of complex infrastructure projects like metro rail construction.

4.4. Dispute Resolution Methods' Assessment

As stated previously, whenever a claim by one of the parties involved arises and is rejected by another, a dispute arises, a situation quite common in the construction industry [27,46]. According to El-Sayegh et al. [27], avoidance and resolution are usually employed for mitigating disputes. Dispute avoidance methods involve risk allocation, negotiation, partnering, and early non-binding neutral evaluation, which are used for preventing disputes from occurring. Resolution methods are further categorized into early (mini-trial/executive tribunal, conciliation, and negotiation) and late methods (mediation, negotiation, litigation, arbitration, adjudication, and dispute review boards (DRB)). 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 [46].

Recent studies on dispute resolution methods, as illustrated in Table 7, apart from assessing [27] and selecting the optimal dispute resolution method with regard to the causes of claims [47], also review novel ones such as online dispute resolution (ODR) methods, which fall under the category of ADR. Various start-ups, corporations, and higher-level organizations, such as the European Commission, provide ODR services [1].

4.5. Claims/Dispute Management Process Models

Claim management focuses on the process of identifying, assessing, and settling costs sustained, resulting from additional work or damages that exceed the agreed contract amount [48]. This process is considered data-intensive and requires analyzing large amounts of distinct 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 AEC projects [49].

Recent studies attempt to address the problems observed in claim and dispute management by developing novel computer-aided claim management process models employing BIM [3,49] and blockchain [50], as illustrated in Table 8. Fundamentally, claim management process models can either be utilized to provide data essential for proper and fast dispute resolution or to prevent even the occurrence of claims.

Table 7. Dispute resolution methods' assessment.

Ref.	Project Type/Sector	Country	Dispute Resolution Method	Findings
[27]	Construction sector generally	UAE	**Dispute avoidance** *(ranked in order of their frequency in the UAE)* • Negotiation; • Risk assignment; • Early non-binding neutral evaluation; • Partnering. **Early resolution** *(ranked in order of their frequency in the UAE)* • Negotiation; • Conciliation; • Executive tribunal/mini-trial. **Late resolution** *(ranked in order of their frequency in the UAE)* • Negotiation; • Arbitration; • Mediation; • Litigation; • Adjudication; • DRB.	• Resorting to court is always the last and the least chosen option for dispute resolution.
[1]	Construction sector, in general	USA	**ADR methods** • Negotiation; • Mediation; • Adjudication; • **ODR.**	• Development of a blockchain-based decentralized system (DCENTR) to expedite prompt and immediate payments, and of a justice-centering voting process (JUS-DCENTR) to allow clear, fast, and affordable dispute resolution. **Future research** on integrating an AI-based dispute assessment component into DCENTR for assessing potential disputes based on past projects' data as well as reducing and resolving them.
[47]	Road construction projects	Nepal	**ADR 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.

4.6. Methods for Modeling and Evaluating Construction Disputes

In this final subcategory, the most important findings of the recent publications regarding the methods for modeling and evaluating construction disputes are presented in Table 9. Recent studies have addressed the issue of modeling disputes either for predicting the occurrence of construction disputes [5,51,52] or for estimating the expected outcome of construction dispute resolutions, which can help professionals decide whether they should embark on dispute resolution or not [53,54]. Researchers also developed a methodology to model the disputes' causes and interrelationships to identify the critical causal

factors leading to the emergence of others and ultimately assist in reducing construction disputes [55].

Table 8. Claims/dispute management process models.

Ref.	Project Phase	Process Model	Findings
[3]	Design	**BIM Tools/Functions** • Collaboration; • Structure analysis; • Clash detection; • Coordination; • 3D models; • Quantity take-offs *(automatic extraction of the quantities contained in a BIM model)*.	**Causes of claims addressed and stakeholder responsible** • Inaccurate quantities—consultant; • Variations between planned and actual quantities—consultant; • Design quality deficiencies or errors—consultant; • Inadequate/incomplete specifications—consultant; • Ineffective communication and interaction between consulting engineers (structural, architectural, and MEP)—consultant; • Design and specifications change—consultant; • Excessive change orders—CA; • Design change—CA.
[49]	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 and parties and Warnings before certain conditions occur.	**Contributions to claim management** • Utilizing BIM to contain all project information saving time required to locate, review, and analyze paper documents. • Easy BIM update 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** • When conventional delivery systems like DBB or DB are used, the provision of a thorough BIM containing the essential information from onset to completion of project is difficult to achieve—IPD provides the necessary collaboration platform.
[50]	Construction	**Blockchain-based system for claim and dispute support** • Application layer (user application); • Contract layer (blockchain extension infrastructure); • Consensus layer; } network • Network layer; } network • Data layer (local). } network network → Blockchain Basic Infrastructure	• The system can generate, transfer, and synchronize blocks based on email communication whenever an event occurs. • System functions: ○ Document search; ○ History tracking; ○ Automated related document extraction; ○ Document authenticity verification. • Securing that the documents during the recording, storing, and managing processes remain reliable to assist claim- and dispute-supporting tasks.

Table 9. Methods for modeling and evaluating construction disputes.

Ref.	Project Phase	Methodology	Findings
[55]	Construction	**A 4-step hybrid method to model disputes' causes and interrelationships** • Identification and verification of causal factors (lit. review); • Data collection (questionnaire survey); • ISM; • MICMAC analysis.	• There are 14 factors causing disputes. • A 6-level ISM hierarchical model of causal factors. • The 6-level ISM hierarchical model of causal factors: ○ The 1st level (root cause)—vague language of contract document; ○ The 6th level (more damaging)—cost overrun. • MICMAC analysis—interrelationships: ○ Six dependent factors: weak drivers and strong dependents (e.g., cost overrun); ○ Six independent factors: strong drivers and weak dependents (e.g., vague language of contract document); ○ Two autonomous (e.g., technical incompetency of the stakeholders).
[5]	Pre-construction	**Hybrid fuzzy–SEM for dispute occurrence probability quantification** • 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 and prevention before construction. • Targeting the proactive reduction in the occurrences of conflicts, disputes, and litigation.
[51]	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.	• The 14 factors with significant association with dispute occurrence: ○ Three project characteristics-related factors: project location, value, and planned duration; ○ Nine skill-related factors: e.g., communication between parties and relationships between parties/individuals, working culture, and skills; ○ **Changes** (the most influential factor); ○ Delays.
[52]	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 and data on eight real estate projects in India). • Variables coded using claim data, experts' interviews and project documentation *(input for the ANN-based model)*. • Development of an ANN-based predictive model. • Developing 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 the decision tree model to identify the most influencing factors for claim occurrence.	• The feasibility and benefits of employing AI/ML techniques for predicting claims are demonstrated. • The developed 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 and 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 revealed six research trends:

- "Assessment of factors leading to claims/disputes";
- "The role of the human factor in construction conflicts";
- "Construction project performance";
- "Dispute resolution methods' assessment";
- "Claims/Dispute management process models";

- "Methods for modeling and evaluating construction disputes".

Regarding the assessment of factors leading to claims/disputes in construction, recent studies have either focused on identifying lists of claims and dispute causes [26–28,30,31] or on investigating the interrelationships between various factors affecting the emergence of claims and disputes, aiming to discover possible patterns of claim occurrence [25,29]. Furthermore, concerning the role of human factors in construction conflicts, researchers have been studying how unethical practices can be minimized and how the behavior and personality characteristics of the parties affect dispute resolution. For example, Pishdad-Bozorgi and Yoon [36] studied how the unethical practices of bid shopping can be minimized. As far as construction project performance is concerned, Sheng et al. [41] investigated how missing a consistent and clear quality information management system affects the emergence of disputes among stakeholders. Regarding the same research trend, in their research, Pradeep et al. [40] aimed to develop a blockchain-based prototype system to ensure that the transactions recorded could better serve audits by offering data authenticity, integrity, and longevity. Moreover, when assessing the methods employed for resolving disputes, recent studies have not only evaluated [27] and selected the most appropriate dispute resolution methods with regard to the causes of claims [47] but have also reviewed novel ones such as online dispute resolution methods, which fall under the category of ADR. Furthermore, recent studies have attempted to address the problems observed in claim and dispute management by developing novel computer-aided claim management process models [3,49,50], which can be utilized to provide data essential for proper and fast dispute resolution or to even prevent the occurrence of claims. Finally, recent studies have addressed the issue of modeling disputes either to predict the occurrence of disputes in construction [5,51,52] or to estimate the expected outcome of construction dispute resolutions, which can help professionals decide whether they should embark on dispute resolution or not [53,54].

Through this content analysis, it was also found that novel technologies such as BIM, blockchain, smart contracts, AI, ML, NN, fuzzy logic, and SEM have recently been employed to study claim management and dispute resolution in the AEC sector. These novel technologies appeared in 12 out of the 27 studies selected for the content analysis, highlighting why these are current trends in this research field. More specifically, the employment of novel technologies was observed in five out of the six identified research trends, i.e.,:

- "The role of the human factor in construction conflicts" [36];
- "Construction project performance" [40–42,44];
- "Dispute resolution methods' assessment" [1];
- "Claims/Dispute management process models" [3,49,50];
- "Methods for modeling and evaluating construction disputes [5,51,52].

Notably, while the first research trend regarding the assessment of causes/factors leading to claims/disputes was the scope of most of the original 231 documents (79), it was the only research trend that did not incorporate any novel technologies.

To better comprehend these terms, it is helpful to present their definitions. Fuzzy logic refers to fuzzy set theory (FST), which can provide a viable tool for modeling subjective information and handling uncertainty where numerical datasets are not available for modeling [5]. The term smart contract first appeared in 1994, when Szabo described it as "a computerized transaction protocol that executes the terms of a contract", suggesting the employment of an automated protocol for easing contractual agreements, decreasing both intentional and unintentional errors, and negating the role of mediators in contract enforcement [56]. Structural equation modeling (SEM) is a class of multivariate techniques combining confirmatory factor analysis (CFA) as a measurement model and regression or path analysis as the structural model. SEM is one of the most convenient advanced statistical analysis methods, having recently emerged in the social sciences, and the perks of utilizing SEM are that it can concurrently examine the association between dependent and independent variables [57]. Blockchain is the underlying distributed ledger technology (DLT) known primarily for underpinning the operation of the Bitcoin cryptocurrency net-

work. A blockchain system can record transactions and validate digital events occurring in a network in the form of encrypted "blocks" and can "chain" all transactions by chronologically storing them across multiple nodes. Blockchain operates on three fundamental elements: consensus mechanisms, cryptography, and decentralization [58]. 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), according to the definition given by the National Institute of Building [59], 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 (e.g., walls, windows, or doors) 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 simplifying the digital data extraction, insertion, modification, or update by the stakeholders involved in the project (owners, contractors, clients, architects, engineers, building officials, and suppliers) [49].

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, 12 of the 27 publications selected for the content analysis, which were found to employ these methods for addressing construction disputes, are presented by project phase, research theme, and cause of claim, as addressed in each article, and it is deduced that AI, ML, and NN [51,52] and fuzzy logic and SEM [5] should be employed during the pre-construction phase of a project or in the early stages of construction to model and evaluate construction disputes. The combination of smart contracts and BIM [44] can be utilized during the construction phase to enhance the current progress payment procedure, making progress payments' preparation and approval easier and less susceptible to disputes, particularly for lump sum projects. Smart contracts and blockchain can be employed during the procurement phase, as proposed by Pishdad-Bozorgi and Yoon [36], who developed a blockchain-enabled smart contract system to ensure system-based trust in the subcontracting procurement process and prevent unethical practices such as bid shopping and trading. Another blockchain-based framework was developed by Sheng et al. [41] with the aim of decentralizing quality information management, thus resulting in a consistent and secure means of management of quality information. Additionally, the combination of smart contracts and blockchain [1] can be employed to facilitate on-time and direct payments, as well as to enable transparent, fast, and inexpensive online dispute resolution. BIM [3,49] and blockchain [40,50], separately, are proposed to be utilized during construction, design, and post-construction for recording, storing, and securing the numerous project data that are essential not only for claim- and dispute-supporting tasks but also for notifying the responsible party before conditions that can lead to claims occur.

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

Ref.	Novel Technologies	Project Phase	Research Theme (Related Content Analysis Section)	Cause of Claims (CCBS Code from Figure 1)
[5]	Fuzzy logic and SEM	Pre-construction	Methods for modeling and evaluating construction disputes (Section 4.6).	-
[44]	Smart contract and BIM	Construction	Construction project performance (Section 4.3).	Payment delays (A5).

Table 10. *Cont.*

Ref.	Novel Technologies	Project Phase	Research Theme (Related Content Analysis Section)	Cause of Claims (CCBS Code from Figure 1)
[50]	Blockchain	Construction	Claims/dispute management process models (Section 4.5).	Inadequate document management (D5). Change in scope (A1); insufficient availability of information (C3).
[40]		Design/construction/post-construction	Construction project performance (Section 4.3).	
[36]	Smart contract and blockchain	Procurement	The role of the human factor in construction conflicts (Section 4.2).	Quality of work (B10).
[1]		Construction	Dispute resolution method assessment (Section 4.4).	Payment delays (A5); ambiguity in contract documents (D1).
[41]		Construction	Construction project performance (Section 4.3).	Quality of work (B10).
[52]	AI/ML/NN	Construction (early stages)	Methods for modeling and evaluating construction disputes (Section 4.6).	Inadequate/incomplete specifications (C2); lack of communication between CA and contractor (E2). Delays in work progress (B1); change in scope (A1); project characteristics (F1, F2),
[51]		Pre-construction	Methods for modeling and evaluating construction disputes (Section 4.6).	
[49]	BIM	Construction	Claims/dispute management process models (Section 4.5).	Insufficient availability of information (C3). Design errors (C1); lack of communication between CA and contractor (E2); changes in quantities, work, or scope (A1); inadequate/incomplete specifications (C2).
[3]		Design	Claims/dispute management process models (Section 4.5).	
[42]	Smart contract	Lifecycle	Construction project performance (Section 4.3).	Contract-related issues (D1, D2, D3, D4, D5).

6. Conclusions

The scope of this perspective paper was to investigate the current state-of-the-art in claim management and dispute resolution research in the AEC sector. It was found that this is a long-time research area with significant popularity in the past 15 years. The bibliographic data analysis using VOSviewer on data from the Scopus scientific literature database returned 791 articles published between 1983 and 2022. The analysis found that Australia, Hong Kong, and the USA contribute significantly to this research field, while the most prominent 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*. In terms of highly cited authors in this field, Cheung, S.O., along with Yiu, T.W., and Fenn, P., are among the most prominent. Furthermore, a co-occurrence author keywords analysis revealed that terms such as "blockchain", "smart contracts", "building information modeling (BIM)", and "claim management" are observed in later periods (after 2020) in the literature with regard to the construction claims and disputes domain. Attempting to shed light on the manner in which these concepts relate to construction claims and disputes, the more recent documents published during the 2020–2022 period were further investigated, revealing six research trends: "Assessment of factors leading to claims/disputes (Section 4.1)", "The role of the human factor in construction conflicts (Section 4.2)", "Effect on construction project performance (Section 4.3)", "Dispute resolution methods' assessment (Section 4.4)", "Claims/Dispute management

process models (Section 4.2)", and "Methods for modeling and evaluating construction disputes (Section 4.6)", leading to a content analysis of 27 journal papers.

Even though this study included a comprehensive selection of papers, echoing the state-of-the-art in research regarding claim management and dispute resolution in the AEC sector, limitations due to employing VOSviewer software and the Scopus database are acknowledged. Bibliometric visualization may provide an easy way to analyze complex bibliographic data and produce simplified results. Still, this simplification can result in a loss of information that may affect the conclusions drawn from such a visualization [20]. That is why bibliometrics should be used supplementally and not as a substitute for expert judgement. Similar research could be conducted in order to obtain more exciting findings with regard to bibliometrics, by employing the CiteSpace software (https://citespace.podia.com/) instead of VOSviewer, since it provides additional features, and using document data from both Scopus and the Web of Science databases.

An important finding of this review was that the contract-related causes of claims were investigated in 6 [1,26,29,31,42,50] out of the 27 research papers selected for content analysis, signifying how important a thorough and project-appropriate contract is for the success of a construction project, which, although not unanticipated, could indicate a possible future direction for the optimization of construction contracts.

Additionally, BIM, blockchain, and smart contracts were found to be more significant for the researchers than AI, ML, NN, fuzzy logic, and SEM since they were implemented in 9 out of the 12 research papers presented in Table 10. 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. Subsequently, 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 the recently emerging technologies such as blockchain and smart contracts, rendering this combination more readily accepted, proving its potential applicability in real construction projects, and indicating a direction for future research.

Another important finding was that novel technologies were utilized in all six identified research trends, apart from the "Assessment of factors leading to claims/disputes" one, indicating a gap regarding the use of novel technologies when assessing the factors leading to construction claims. Moreover, considering that in this research trend, only two of the seven studies [25,29] focused on examining the interrelationships between various factors affecting the emergence of claims and disputes, future researchers could concentrate on utilizing novel technologies, e.g., SEM, to investigate these interrelationships. Another research gap was that very few applications of novel technologies were observed in the "The role of the human factor in construction conflicts" [36] and "Dispute resolution methods' assessment" [1] research trends. In contrast, in the "Construction project performance" [40–42,44], "Claims/dispute management process models" [3,49,50], and "Methods for modeling and evaluating construction disputes [5,51,52], the applications of novel technologies were presented more often. To this end, future researchers could investigate how novel technologies could be further employed in the "Dispute resolution methods' assessment" research area, e.g., by employing AI or ML to choose the ADR method most appropriate for the causes of claims.

Nevertheless, the literature revealed that there are still issues and obstacles of these novel technologies to be addressed when it comes to applying them to claim management in construction and maintenance contracts, mainly due to the different levels of familiarity the parties involved in construction possess with these methods. Specifically, for the application of BIM, the lack of organizational capability and the need for their organizational culture to be reformed have been found by researchers to be the most significant barriers to its application [60,61]. Similar barriers to the application of novel technologies have been found by researchers in other construction management and infrastructure maintenance domains, such as BIM and blockchain in construction safety [62,63] and ML in the prediction of bridge

deck deterioration [64]. Nevertheless, the power of blockchain technology to transform the construction industry is verified in research work by Morteza et al. [62], who also agree that understanding the challenges and obstacles to its successful application on all aspects of construction management, including contracts, procurement, safety, and scheduling, is the way forward for research in this field. Future research on providing recommendations or developing a policy framework on how such obstacles could be overcome would be helpful in facilitating the use of novel technologies in construction management.

To conclude, a significant research gap was observed regarding the combination of BIM, blockchain and smart contract applications in road projects, as only three out of the 27 articles analyzed focused on this project type (in Sri Lanka [25], India [26], and Nepal [47]). 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, if the level of familiarity that public road contracting authorities have with BIM, blockchain and smart contract applications in general and on specific project types is concurrently studied. To this end, this research team will continue to work toward facilitating the public sector's entry into the era of Industry 4.0 in construction. Our proposed future research will 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.

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Abbreviations

Abbreviation	Explanation
ADR	Alternative dispute resolution
AEC	Architecture, engineering, and construction
AHP	Analytical hierarchy process
AI	Artificial Intelligence
ANN	Artificial neural network
BIM	Building information modeling
BOT	Build–operate–transfer
CA	Contracting authority
CCA	construction contract administration
CCBS	Causes of claims breakdown structure
CDN	Construction dispute negotiation
CFA	Confirmatory factor analysis
CSV	Comma separated values
DBB	Design–bid–build
DLT	Distributed ledger technology
DRB	Dispute review boards
EPC	Engineering procurement and construction
FGD	Focus group discussion
FIDIC	International Federation for Consulting Engineers
FST	Fuzzy set theory

IoT	Internet of Things
IPD	Integrated project delivery
ISM	Interpretive structural modeling
KPIs	Key performance indicators
MCKPIs	Most critical key performance indicators
MEP	Mechanical, electrical, and plumbing
MICMAC	matrix cross-reference multiplication applied to a classification
ML	Machine learning
NEC	New engineering contract
NN	Neural network
ODR	Online dispute resolution
POP	Product organization process
PPP	Public–private partnership
PPS	Project procurement system
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analyses
QUOROM	QUality Of Reporting of Meta-analyses
RD	Reactive devaluation
SEM	Structural equation modeling
SJR	SCImago Journal Rank
SQ	Scopus quartile
Sub	Subcontractor
TLS	Total link strength
UAE	United Arab Emirates
VOS	Visualization of similarities

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