# Performance Management in Civil Engineering: A Systematic Literature Review

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# PERFORMANCE MANAGEMENT IN CIVIL ENGINEERING: A SYSTEMATIC LITERATURE REVIEW

*Scientific paper*

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**Abstract:** The construction industry is generally one of the fundamental industries of a country, weighing between 5 to 10% of the gross domestic product. Rapid changes in the construction environment require a great deal of effort for a company or project manager to maintain the project successfully. To do so, applying performance management is of crucial importance. Therefore, a systematic literature review was conducted to detect new trends and highlight the evolvement of this research topic. The conducted bibliometric analysis resulted in 1240 documents published in Scopus and Web of Science databases in the period from 2000–2021. The bibliometric indicators, network citations, and multivariate statistical analysis were obtained using JabRef, OpenRefine, Excel, and VOSviewer tools. The co-occurrence analysis showed three keywords clusters as current research hotspots that may be considered as potential research topics in the future: (1) value management in the construction industry, (2) organisation innovation and knowledge management in a particular company, and (3) project management tools and techniques for a particular construction project.

**Keywords**: Performance management; construction sector; systematic literature review; science mapping.

# 1 INTRODUCTION

The construction industry is generally one of the fundamental industries of a country (weighing between 5 to 10 % of the gross domestic product [1]), and is majorly driven by investment projects of different sizes and volumes. Despite good ideas, great efforts, and the high stakes and expectations of all involved stakeholders, many of those projects do not end with success. The reasons for projects' failures are various, but can be summed up as a lack of understanding of the project requirements as well as the constraints necessary for overall success (delivered by the due date, within budget, and to some level of quality, performance, and/or scope), but also as a lack of clearly defined success indicators. Adequate project and performance management throughout the whole life cycle of construction projects can significantly improve their outcomes and success rates.

In the literature, there are review papers and bibliometric research dealing exclusively with performance management in civil engineering, focusing mostly on performance indicators [2-7] and/or performance measurement approaches [8-15] based on the Iron Triangle, i.e. the 'Triple Constraint' concept. Regardless of the fact that the Iron Triangle, throughout the years, became the standard for routinely assessing project performance [16] and is an effective way to communicate the interrelationships between the central success criteria (time, cost, and quality) [13,17-20], more complex projects have shown that it needs to be broadened with other project management concepts, such as scope [16,20-22] and risk [6,11,23-25]. Over the years, various approaches and frameworks to systematically measure performance [6,7,9,11] and define precise performance areas and indicators [10,12-15,26-29] have been developed. However, to the best of our knowledge, there is no work published to date systematically and quantitatively assessing the scientific evolution of literature by referring to the theory and practice of performance management in civil engineering from a bibliometric perspective. To contribute to fulfilling this limitation, this study aims to detect the characteristics of the worldwide literature on performance management in the field of interest through a statistical analysis of the scientific research published in Scopus and Web of Science (WoS) databases from 2000–2021.

This study provides a summary of the global research on performance management in civil engineering including scientific publication growth and science mapping, aiming to identify the emerging and research hotspots and overall development of the topic. The findings of this article could prove useful for the academic community in identifying the gaps and potential opportunities in the current knowledge and in suggesting the pathways for future research.

# 2 RESEARCH METHODOLOGY

To gain a bibliometric perspective of performance management in civil engineering, several review methods can be used for analysing the existing literature and creating or extending the current body-of-knowledge, such as a critical review, literature review, meta-analysis, systematic search, and scientometric analysis [30-32]. It is almost equally important to retrieve as much quantitative and qualitative information in a systematic way. Therefore, the concept of bibliometrics, as a systematic and quantitative literature review, enables a transparent and detailed systematic method for the qualitative analysis and synthesis of information as well as a quantitative, objective-oriented approach that includes a statistical analysis of gathered bibliometric data [32]. Pickering and Byrne [33] highlighted the importance of this method when dealing with transdisciplinary research, but it can be used in any other interdisciplinary and/or single-disciplinary research when there is a need to identify the geographical, scalar, theoretical, and methodological gaps in the literature.

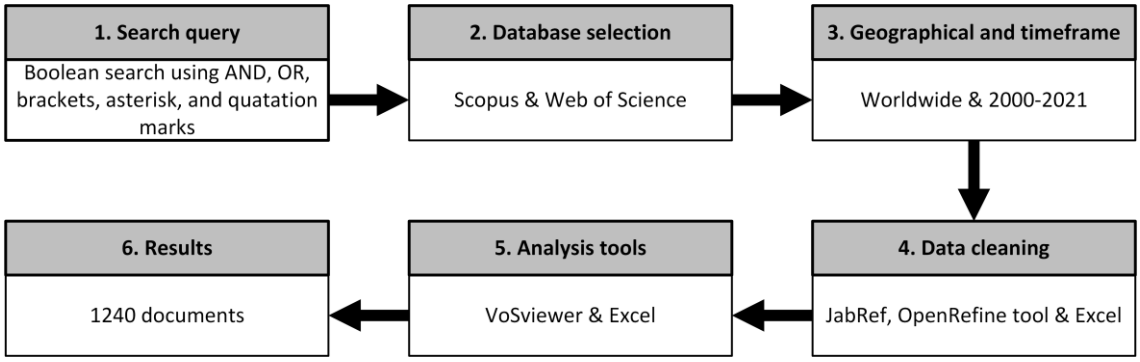


**Figure 1 Methodological framework of the conducted bibliometric analysis of performance management in civil engineering (2000–2021)**

Based on the aforementioned literature and five-step approaches [34, 35], a similar methodological framework was adopted for the bibliometric analysis (Figure 1) comprising (1) conceptualisation of research, (2) collection of bibliometric data, (3) analysis of the collected data, (4) visualisations, and (5) interpretation and creation of new knowledge.

At the very beginning, the research questions and appropriate bibliometric methods were defined. This resulted in forming the search query selecting the database (both shown in Figure 1). To dive more deeply into the specifics of performance management in civil engineering, the query was built with three main segments interconnected with the Boolean operator 'AND', whereas each segment consisted of at least two fields linked with the 'OR' operator. The search query was used in both the Scopus and WoS databases, as shown in Table 1.

**Table 1 Search query used in both Scopus and Web of Science (WoS) database**

| Search query | Construction of query |
|---|---|
| Part 1 | 'performance management' OR 'value management' |
| Part 2 | ('project*' OR 'industry' OR 'sector' OR 'company' OR 'firm') AND ('building' OR 'construction') |
| Part 3 | ('stakeholder*' OR 'client*' OR 'partner*' OR 'private sector' OR 'public sector' OR 'user*' OR 'owner*') OR ('process' OR 'framework' OR 'criteria' OR 'measures' OR 'indicator*' OR 'service*' OR 'evaluation' OR 'overrun*' OR 'plan*' OR 'factor*' OR 'performance' OR 'productivity' OR 'excellence' OR 'satisfaction' OR 'value' OR 'measurement' OR 'objective' OR 'value for money' OR 'level of service' OR 'profitability') |
| Final query | Part 1 AND Part 2 AND Part 3 |

The aforementioned was an important driver of the conceptualisation of the research to collect all necessary bibliometric data for future analyses. Throughout the years, various criteria have been used to evaluate project success and manage its performance. The traditional three criteria (time, cost, and quality), well-known as the Iron Triangle of project management [8,36], are no longer responsive to all project managers' needs for today's complex projects and other performance aspects [14,15], especially as concerns the best value for money. Although many scholars and practitioners believe that success cannot be measured solely based on these three criteria because project success is a very complicated issue [9], models based on quantitative and qualitative performance indicators remain scarcely used in the construction industry. Therefore, part 3 of the search query embraces performance measures, e.g. the value for involved stakeholders in term of key performance indicators [6,10-12] as well as value management and dynamic system methods and concepts such as 'Earned Value Management' [5,37,38], system dynamics [39-41], and value for money [12,42-44].

# 3 RESULTS AND DISCUSSION

## 3.1 Database selection and data cleaning

Based on the aforementioned framework, in this study, records are collected from both the Scopus and WoS databases and then are merged. Considering such a large dataset improves the analysis and its conclusions not only by providing a more global perspective of bibliometric analysis, but also by eliminating any dependency of the results on both databases while simultaneously following good practices for conducting a systematic literature review and/or scientific evolution analysis.

In the present study, the document type was restricted to scientific articles, reviews, conference papers, and conference reviews for the Scopus database, and scientific articles, proceeding papers, and reviews for the WoS Core Collection. The search query was employed in the 'Topic' field of the WoS Core Collection, and the 'title, abstract, keywords' field of the Scopus database. The timespan was set to 2000–2021.

After gathering the records from both databases, the results from categories irrelevant to performance management in civil engineering were removed. As the Scopus and WOS databases use different frames to index documents' bibliographic information, a normalisation of the field was performed followed by merging data and removing duplicates by means of JabRef, the OpenRefine tool, and Excel. As a result of the retrieval and refining procedures, 1240 documents were collected from the databases and further analysed.

## 3.2 Global statistics

From 1240 documents collected from the two databases, 64.0 % (793) records were journal articles, 29.9 % (371) were conference papers, 3.1 % (39) were reviews, and 3.0 % (37) were book/book chapters. The publications were retrieved from 681 scientific journals/repositories with an average of 2.8 authors per publication, and with a great majority (83.6 %) being multi-authored. The evolutions of the total number of publications (TP) and total number of citations (TC) of performance management in civil engineering (2000–2021) are presented in Figure 2. It shows a significant increase in total publications in the year 2005 in relation to period 2000–2004, with steady fluctuation in period 2005–2015, and again increases from 2016 till today. However, the number of articles has been increasing linearly during the whole observed period of 2000–2021. During the last five years, almost half of all articles (615) have been published. This continuous yearly rise of published articles indicates the intensity of researchers' contributions to this field of managing projects in civil engineering and can be seen as a driving factor for the industry. This confirms the high interest in the subject of improving people, processes, and performance in the last five years, especially considering the last years influenced by the Covid-19 pandemic.

Figure 2 also gives insight into the evolution of the TC concerning performance management in civil engineering (2000–2021) and total of 13899 citations at the moment (search on Scopus and WoS 22 November 2021). Concerning the evolution of the TC, 2005 shows the biggest yearly increase of citations (370 %), whereas 2010 has the highest number of citations per year (1523). In 2005, the increase in citations per year matches the increase in publications per year. The reasons for this are undoubtedly many, but it can be argued that the development of project management as a discipline as well as the presence of Project Management Institute's 'Project Management Body of Knowledge' [37,45] and International Project Management Association (IPMA) Competence Baseline 3.0 [46] publications gave a strong impact to the community, e.g. to focus their drivers on the performance of their projects and projects' environments. Nonetheless, in the period from 2005 to 2011, the majority of important development publications in the field resulted in their high yearly and overall citations. Then, there is a decline in the yearly citations of newly published manuscripts, averaging 485 citations per year during the period of the last five years. For sure, gaining momentum with new approaches in performance management, focusing on people and processes to create project value, and implementing such into project management methodologies [37, 47] sets the drivers for performance management as a pivotal aspect in managing projects in civil engineering. The rising number of different journals' special issues focusing on project performance and performance management will surely boost this whole field of study.

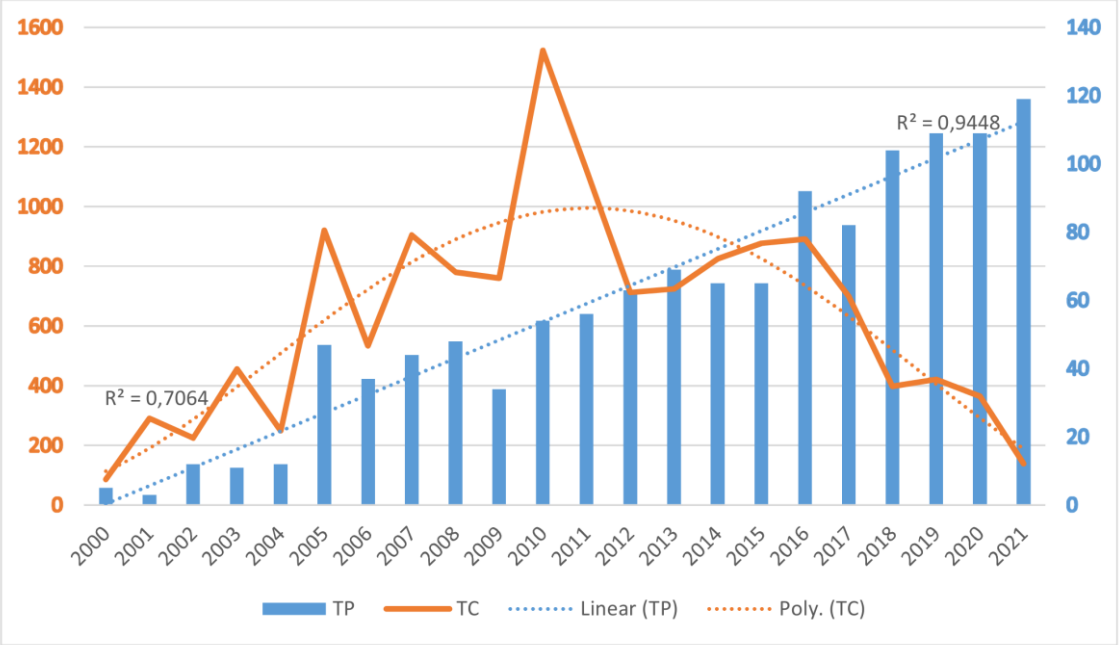


**Figure 2 Evolution of the total number of publications (TP) and total number of citations (TC) of the performance management in civil engineering (2000–2021)**

It can be inferred that the topic has not arrived at its maturity stage, and will likely continue to attract considerably more research. As a result, the TP and TC have been considered as measures of the scientific productivity, influence, and interest in the subject in following analysis and discussion.

### 3.3 Journal statistics

The publications in the field of performance management in civil engineering are retrieved from a wide range of journals and different knowledge areas: 683 journals and conferences. These journals are distributed in different knowledge areas such as engineering, business and management, computer science and technology, social sciences, environmental science, and economics. This implies that the performance management topic has attracted wide attention from many researchers in various fields. Among the top 10 sources (Table 2), journals from both Scopus and WoS databases are equally represented. The top 10 most productive sources, all journals, publish 19.8 % of the TP and simultaneously are cited over 37.0 % of the TC. In particular, the International Journal of Productivity and Performance Management is the most productive, with 77 publications (6.2 %), whereas the International Journal of Project Management had the most impact on other researchers, with 1317 citations (9.5 %). The rankings of the sources according to the local h-index and TC are almost equal. In contrast, the conferences have a low local h-index (i.e. h-index calculated from dataset) and total citations per article (TC/TP), indicating their low impact on the community. The top three publishers according to TC/TP (International Journal of Project Management, Construction Management and Economics, and Journal of Cleaner Production), are ranked 1$^{st}$, 3$^{rd}$, and 8$^{th}$ considering the number of articles, indicating a high quality of the publications of these journals.

**Table 2 Top 10 journals for performance management in civil engineering (2000–2021)**

| Sources | Total number of publications (TP) | Total number of citations (TC) | TC/TP | Local h-index | Impact Factor (IF) (2020) | IF (5 years) | CiteScore (2020) | Scientific Journal Rankings (SJR) (2020) | Best quartile |
|---|---|---|---|---|---|---|---|---|---|
| International Journal of Project Management | 24 | 1317 | 54.9 | 19 | 7.172 | 9.222 | 16.4 | 2.762 | Q1 |
| International Journal of Productivity and Performance Management | 77 | 769 | 10.0 | 16 | - | - | 3.5 | 0.418 | Q2 |
| Construction Management and Economics | 17 | 766 | 45.1 | 14 | - | - | 5.6 | 0.88 | Q2 |
| Journal of Construction Engineering and Management | 31 | 572 | 18.5 | 14 | 3.951 | 4.513 | 6.4 | 0.967 | Q1 |
| Journal of Management in Engineering | 19 | 564 | 29.7 | 13 | 6.853 | 6.212 | 7.9 | 1.645 | Q1 |
| Engineering Construction and Architectural Management | 32 | 560 | 17.5 | 12 | 3.531 | 4.129 | 4.0 | 0.585 | Q1 |
| Automation in Construction | 16 | 330 | 20.6 | 11 | 7.700 | 8.000 | 12.0 | 1.837 | Q1 |
| Journal of Cleaner Production | 6 | 186 | 31.0 | 6 | 9.297 | 9.444 | 13.1 | 1.937 | Q1 |
| Journal of Civil Engineering and Management | 8 | 99 | 12.4 | 6 | 2.957 | 3.014 | 5.4 | 0.529 | Q2 |
| International Journal of Construction Management | 15 | 101 | 6.7 | 6 | - | - | 4.7 | 0.510 | Q1 |

Based on the aforementioned, seven of the top 10 journals are in the 25 % top journals of a category e.g. Q1, whereas their CiteScores (2020) are over 3.5 and Impact Factors (2020) are over 2.957 (if they are indexed in the WoS). Another attention-grabbing aspect is the relationship between the local h-index and TP. In four journals (International Journal of Project Management, Construction Management and Economics, Journal of Cleaner Production, and Journal of Civil Engineering and Management) the percentage between the local h-index and TP is 75.0 % and higher, whereas nine journals have ratios above 37.5 %. Knowing such and combining this with information regarding the TC and TC/TP gives valuable information to researchers and their submissions, e.g. if they get accepted for publication in these journals, there is a high probability that they will have an impact on the wider community.

To find the most relevant authors, bibliometric indicators such as the quantity of the author's publications, number of citations received, and h-index are often used. Such a process requires 'debugging' the repetition of authors' names and affiliations. Owing to the frequent updates and changes to the WoS interface during the writing of this paper, there were frequent, but temporal, desynchronisations of the database. Therefore, the highly cited papers are provided below, but the most relevant authors of the topics are not.

The 'Highly Cited Papers', as seen by Clarivate Analytics, are 'papers that perform in the top 1% based on the number of citations received when compared to other papers published in the same field in the same year'. Accordingly, it can be concluded that this tag varies over time and with the knowledge area. Therefore, this research is a multidisciplinary one, and from the perspective of an evolution analysis, the tag 'Highly Cited Papers' is used for those published manuscripts receiving over 100 citations throughout the years. This results in just 18 papers

out of 1240, or 1.5% of the analysed dataset. These papers are shown in Table 3 together with their source, year of publication, and total citations over time.

**Table 3 Highly Cited Papers on performance management in civil engineering (2000–2021)**

| Title | Source | Year | TC |
|---|---|---|---|
| How information management capability influences firm performance | MIS Quarterly: Management Information Systems | 2011 | 508 |
| Burnout and Work Engagement: A Thorough Investigation of the Independency of Both Constructs | Journal of Occupational Health Psychology | 2010 | 370 |
| Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects | International Journal of Project Management | 2010 | 291 |
| Diagnosing Customer Value: Integrating the Value Process and Relationship Marketing | British Journal of Management | 2001 | 289 |
| Building operation and energy performance: Monitoring, analysis and optimisation toolkit | Applied Energy | 2013 | 207 |
| Selection of performance objectives and key performance indicators in public-private partnership projects to achieve value for money | Construction Management and Economics | 2009 | 195 |
| Six Principles of Effective Global Talent Management | MIT Sloan Management Review | 2012 | 190 |
| Consumer-retailer emotional attachment: Some antecedents and the moderating role of attachment anxiety | European Journal of Marketing | 2010 | 142 |
| Analyzing project management research: Perspectives from top management journals | International Journal of Project Management | 2009 | 132 |
| A review of decision-support tools and performance measurement and sustainable supply chain management | International Journal of Production Research | 2015 | 129 |
| Critical success factors for value management studies in construction | Journal of Construction Engineering and Management | 2003 | 126 |
| Comparing the quality management practices in UK SMEs | Industrial Management & Data Systems | 2008 | 125 |
| Managerial effectiveness of government performance measurement: Testing a middle-range model | Public Administration Review | 2007 | 123 |
| Operation and performance of international manufacturing networks | International Journal of Operations and Production Management | 2003 | 117 |
| Analyzing project management research: Perspectives from top management journals | International Journal of Project Management | 2009 | 114 |
| Competency-based model for predicting construction project managers' performance | Journal of Management in Engineering | 2005 | 111 |
| Redefining performance measures for construction project managers: An empirical evaluation | Construction Management and Economics | 2003 | 109 |
| In public sector organisations: A public-value management perspective | Journal of Information Technology | 2014 | 107 |

Out of the 18 identified Highly Cited Papers, the oldest is published in 2001, and the latest in 2015. Throughout the period of 2000–2021 these papers accumulated 3385 citations (24.4%). By overlapping the citations peak (Figure 2) and data from Table 3, it becomes more evident that 2010 and 2011 were the years when some of the most important papers were published. During those two years, 110 manuscripts were published, and four of them have been tagged as 'Highly Cited Papers' and have been cited 1311 times, i.e. 9.4% of the total citations for performance management in civil engineering (2000–2021). Additionally, this list gives even more credit to the International Journal of Project Management as three 'Highly Cited Papers' out of 24 are published in it, with 537 citations (i.e. 40.8% of the journal's TC). Even if these three papers, and their data, were removed from Table 2, the local h-index of the International Journal of Project Management remains the same. This shows that this journal not only nourishes the best research at the time and creates state-of-the-art research serving as a body of knowledge for future research and

involved researchers, but also gives certainty regarding an impact on the wider community. Certainly, conducting the evolution analyses attaches addition importance to the International Journal of Project Management and sets it as a driver for the project management body of knowledge, especially when it comes to performance management.

### 3.4 Research hotspots

The analysis of keywords in a research field provides an opportunity to discover underlying information that sometimes is not self-evident. Therefore, qualitative visualisation tools can help to gain additional insights. In this study, based on the search queries, author keywords were used to obtain a reproducible and readable analysis of the retrieved data from Scopus and WoS databases. Figure 3 gives an overall map of authors' keywords co-occurrences in the performance management field in civil engineering from 2000–2021.

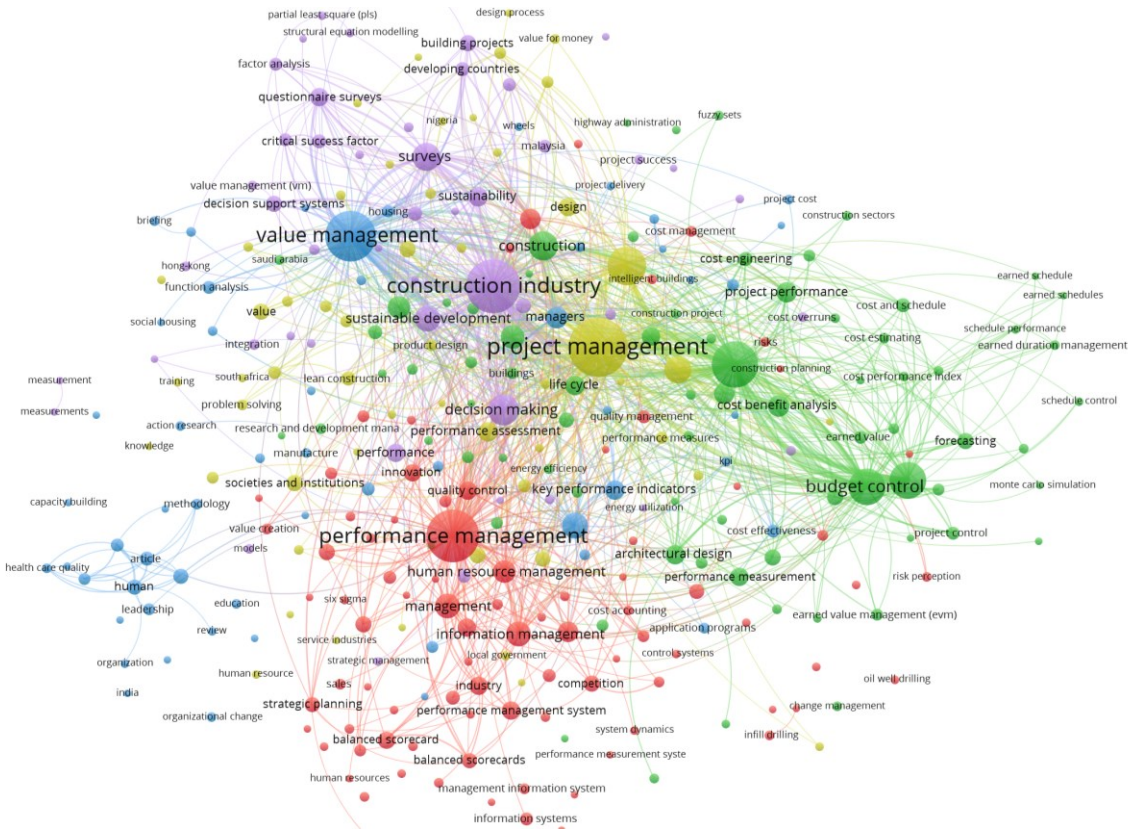


**Figure 3 Overall bibliometric map based on co-occurrence of authors' keywords in performance management in civil engineering (2000–2021)**

To gain a more in-depth view, clustering was performed in VOSviewer software and a new bibliometric map was created (Figure 4). This map was created for the minimum number of keyword occurrences of 20 and resulted in 200 nodes and 14753 links, grouped in three clusters: (1) value management in the construction industry, (2) organisation innovation and knowledge management in a particular company, and (3) project management tools and techniques for the particular construction project.

Cluster 1 (shown in red in Figure 4) is the most significant cluster, with 89 keywords. The main concern of this cluster is the value framework of competencies, benefits, outcomes, and deliveries for various stakeholders in the construction industry. There are strong connections between keywords within this cluster but also with the other two clusters, as the level of importance from the industry (red cluster) is brought down on a company level (green cluster) and subsequently on a project level (blue cluster). The focus in Cluster 1 is paced on decision-making processes and critical success factors for managing value in the construction profession and construction industry.

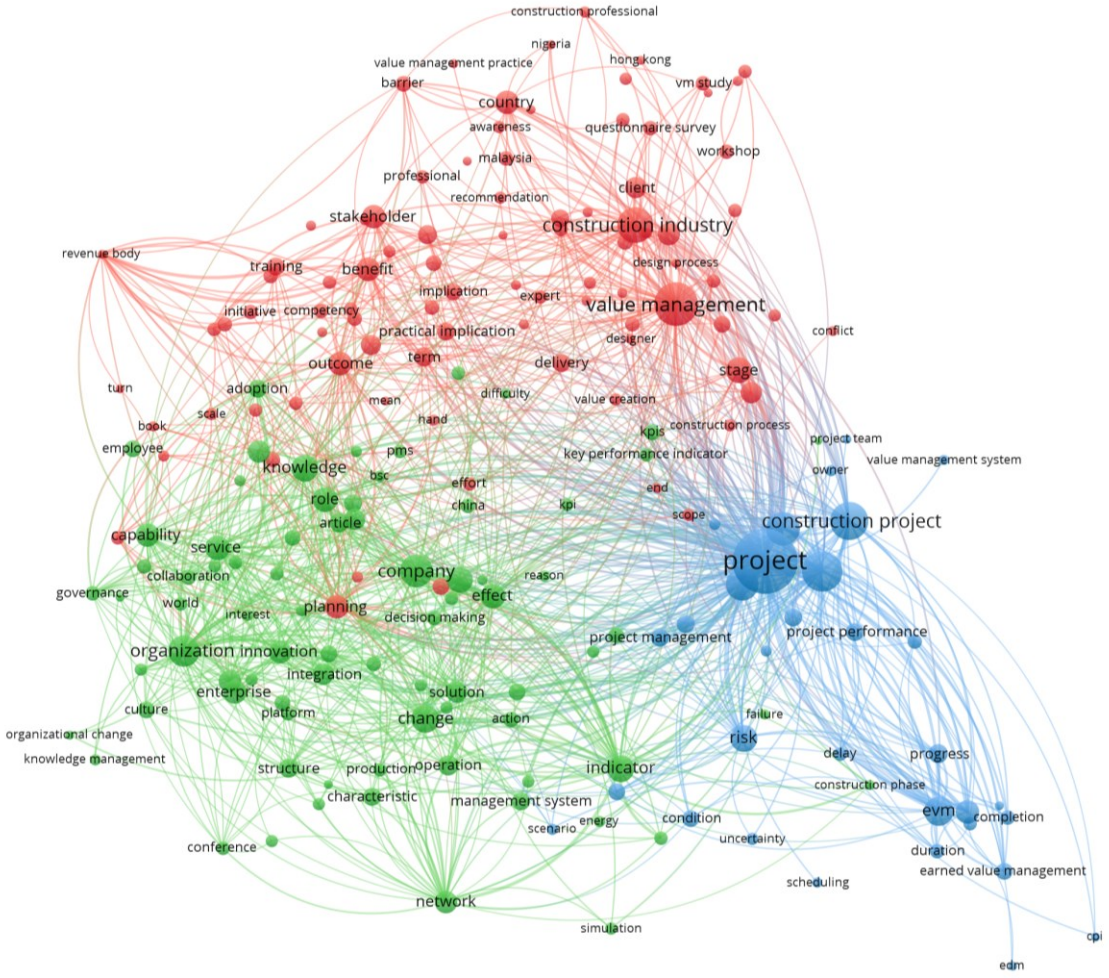


**Figure 4 Clustered bibliometric map**

Cluster 2, shown in green in Figure 4, has 78 keywords concerned with organisational innovation and knowledge management in a particular company, focusing on networks and systems for integrating different services to achieve the best possible performance. This cluster is well-interconnected, with 33 keywords from Cluster 3 in blue in Figure 4, as it offers adequate tools and techniques for managing value in construction projects on an operational level.

In the period from 2000–2010, the key areas of research were mainly related between organisation innovation and knowledge management in a particular company and value management in the construction industry, placing the Iron Triangle in the centre of businesses interlacing the 'red' and 'green' clusters to achieve value with their outcomes. During 2010-2015, the researchers have focused on particular challenges of industry and company by exploring tools and techniques (‘blue’ cluster) to precisely define performance indicators and set performance measurements in all phases of a construction project. Since 2015 their focus is increasingly shifted toward placing the ‘blue’ cluster in the centre, and on connecting the 'red' and 'green' clusters to achieve the best possible value in the best possible way.

## 4 CONCLUSIONS

In the present study, different bibliometric methods were used to analyse 1240 publications on performance management in civil engineering (2000–2021). Based on the defined methodological framework and research query, records were collected from both Scopus and WoS databases, and then were merged and analysed using JabRef, OpenRefine tool, and Excel.

The conducted systematic literature review gives the following insights.

- The evolution of the number of publications and total number of citations (the number of publications continuously increases with a linear annual growth rate and a fluctuating number of citations over the period 2000–2021)
- Top 10 journals in the field (as attuned with their local h-index values) regarding the performance management in civil engineering
- Overview of Highly Cited Papers on performance management in civil engineering (2000–2021)
- Three research hotspots for future research (e.g. (1) value management in the construction industry, (2) organisation innovation and knowledge management in a particular company, and (3) project management tools and techniques for the particular construction project)

As with every bibliographical research, this study possesses some limitations, mainly related to the intrinsic nature of the bibliometric approach. First of all, the keywords and query were chosen based on previous literature and several trials to ensure scientific significance and avoid pollution in the dataset. However, certain related works may not have been covered by the proposed search or, as noticed during writing, by the increase of Special Issues for the particular topic of performance management in civil engineering. Of course, adding more keywords and/or databases might increase the noise in the sample and the risk of including unrelated articles. Second, this study used both Scopus and WoS databases as the most relevant databases, but the search could be improved with the inclusion of other databases and even grey literature.

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