A scientometric analysis and review of construction labour productivity research

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Abstract

Purpose – Labour productivity in construction has fallen behind other industries in most of the world and has declined continuously for decades. Although several scholarly research projects have been conducted to salvage the prevalent low labour productivity in construction, contractors in the construction industry have continued to grapple with the devastating impact of low productivity. The purpose of this study is to determine key areas of focus necessary to promote productivity growth in construction.

Design/methodology/approach – Bibliometric and scientometric assessments were conducted to map the existing construction labour productivity (CLP) studies and establish key focus areas in the research domain. The keywords "Construction Productivity" OR "Construction Labour Productivity" OR "Construction Labor Productivity" OR "Construction Worker Productivity".

Findings – Emerging trends in the CLP research field are reported. The study also determined the most productive authors and collaboration among authors, most productive journals, most active regions and publications with the highest impact in CLP research.

Research limitations/implications – Documents published in the Scopus database were considered for analysis because of the wider coverage of the database. Journal and conference articles written in English language represent the inclusion criteria, while articles in press, review, book chapters, editorial, erratum, note, short survey and data paper were excluded from analysis. The study is also limited to documents published from 2012 to 2021.

Practical implications – The study brought to the awareness of the industry practitioners and other construction stakeholders, the key knowledge areas that are critical to promoting productivity growth in construction.

Originality/value – Except bibliometric analysis, previous research studies have used different approaches to investigate productivity in construction. The study presented future research directions through the emerging knowledge areas identified in the study.

Keywords Bibliometric, Construction, Contractor, Labour productivity, Literature, Review, Scientometric

Paper type Literature review

1. Introduction

Although labour productivity in the construction industry is essential for the survival and growth of construction organisations (Alaghbari *et al.*, 2019), labour productivity in construction has fallen behind other industries in most of the world and has declined continuously for decades (Neve *et al.*, 2020). A country with greater productivity seems to have a great financial structure and growth (Dixit *et al.*, 2019). Over the years, construction productivity trends are studied, and there are reports of a decline in the total factor productivity of the majority of the countries (Dixit *et al.*, 2019; Wang *et al.*, 2013). About

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30–40% of the total construction project cost is expended on labour (Shree *et al.*, 2015); therefore, improving labour productivity is a major concern for any profit-oriented organisation in construction (Agrawal and Halder, 2020). Since the early 20th century, the term labour productivity is usually defined as the relationship between output and input (Jarkas and Bitar, 2012). Production efficiency (output) can be enhanced by putting organisations' resources (input) to optimum use (Rane *et al.*, 2017). Construction labour productivity (CLP) research domain has continued to attract interest of researchers in developed and developing countries, which has led to several interventions geared towards CLP improvement. Some scholars have identified factors that hinder the growth of labour productivity on construction projects. For example, Agrawal and Halder (2020), Durdyev and Ismail (2016) and Hiyassat *et al.* (2016) are some of the studies undertaken in developing countries that investigated the prevalent factors that militate against productivity growth in construction. Moselhi and Khan (2012), Chan and Kaka (2007), Dai *et al.* (2007), Durdyev and Mbachu (2011) and Karimi *et al.* (2017) are studies conducted in developed countries towards achieving similar objectives. Some scholars have not only identified the CLP influencing factors but further used system dynamics in the form of qualitative model to address factors affecting CLP (Jalal and Shaor, 2019; Nasirzadeh and Nojedehi, 2013; Palikhe *et al.*, 2019). Some scholars proposed models to predict labour productivity in construction (Golnaraghi *et al.*, 2019; Jang *et al.*, 2011; Tsehayae and Fayek, 2016). Respectively, Golnaraghi *et al.* (2019) and Dissanayake *et al.* (2005) use how artificial intelligence and computational intelligence models can be used to predict labour productivity. Tsehayae and Fayek (2016) establish the role of work sampling proportion in CLP modelling and develop a system modelling approach to assist researchers and practitioners analyse productivity influencing factors alongside work sampling proportions. Mlybari (2020) adopted computing techniques to predict CLP. Pan *et al.* (2019) employed Political, Environmental, Social, Technological, Economic and Legal (PESTEL) analysis to develop strategies for productivity improvement. Arising from these studies are contributions to improve the performance of labour productivity in construction. Notwithstanding the numerous investigations, the global construction industry has demonstrated a decline in productivity when compared to other industries over the past two decades (Chingara and Moyo, 2014; Thomas and Sudhakumar, 2013). Researchers in various construction management domains have begun to adopt smart practices such as scientometric and bibliometric analysis, building information modelling (BIM) and advanced creative methodological approach such as causal layered analysis (CLA) (Inayatullah, 2019) to address complex subjects for performance improvement. It is also important to start exploring these tools for CLP performance improvement. Comprehensive understanding of a specific research area can better be achieved through a review of literature. To date, the review-based CLP studies (Dixit *et al.*, 2019; Hamza *et al.*, 2019; Hasan *et al.*, 2018) have been conducted manually, leaving possibilities for subjectivity and bias (Hosseini *et al.*, 2018). To address this bias, a bibliometric analysis of the existing studies in CLP research will be done. Bibliometric indicators have become essential to the scientific community to estimate the state of the art of a given topic and reveal new knowledge area in a given field (Mooghali *et al.*, 2012). Using the analysis to map the existing studies, this study answered the question of what are the emerging knowledge areas in the CLP research field?. The study presented the most productive authors and collaboration among authors, most productive journals, most active regions, publications with the highest impact in CLP research and ultimately, the emerging trends in the CLP research field. The study discussed research gaps in the CLP domain and suggested future scholarly research work for the CLP research community.

2. Data source

The study summarised 2012–2021 publications in the labour productivity field of the construction industry. Bibliometric analysis was conducted to achieve the objectives of the

study. Bibliometric analysis has been applied to diverse research fields to achieve specific research objectives. Some of the research fields include sustainability (Olawumi *et al.*, 2018), health and safety (Vigneshkumar and Salve, 2020), green building (Wuni *et al.*, 2019), medicinal leech therapy (Senel *et al.*, 2020), disaster management (Sood and Rawat, 2021), women in construction (Akinlolu *et al.*, 2020a, b). The analyses in these studies allow a more comprehensive systematic review than the conventional review approach (Vigneshkumar and Salve, 2020). For this research, data were extracted from the Scopus database because of its greater number of construction-related publications as opposed to the Web of Science database (Ahmad *et al.*, 2021; Akinlolu *et al.*, 2020a, b; Hosseini *et al.*, 2018; Olawumi *et al.*, 2018; Vigneshkumar and Salve, 2020; Yi and Chan, 2014). The keywords "Construction Productivity" OR "Construction Labour Productivity" OR "Construction Labor Productivity" OR "Construction Worker Productivity" were used to search publications in the Scopus database, which produced 528 publications (Figure 1). The search strings were adopted because they produced relevant CLP articles that were more specific to the objective of this study. The field limit the retrieved articles from the Scopus database to labour/worker productivity articles that are specific to the construction industry. The Scopus database was explored by the authors using "search within" article title, and data were retrieved from 27 October, 2021 to 31 October, 2021. The search yielded 528 documents. The database was subjected to a process of filtering. Articles in press, articles not written in English language, reviews, book chapters and erratum were eliminated from the list of publications. Only journal and conference articles were retained for analysis. As presented in Figure 1, the retained 460 articles were selected and exported from the Scopus database in Excel format. The Excel data were subsequently uploaded to VOSViewer (version 1.6.16) software, where the required analyses were conducted.

The VOSViewer software (version 1.6.16) was developed by Van Eck and Waltman (2010) to analyse and visualise bibliometric networks. Distance between two nodes indicates the proximity of element of analysis to each other (Van Eck and Waltman, 2017; Vigneshkumar and Salve, 2020), while note colours indicate elements within the same cluster. A special text mining feature that is suitable for visualising large networks is part of the feature of VOSViewer (Van Eck and Waltman, 2010). Van Eck and Waltman (2017) provided a comprehensive detail about VOSViewer and its working mechanism. To support the review of literature, VOSViewer has been recently applied in offsite construction research (Hosseini *et al.*, 2018; Vigneshkumar and Salve, 2020), construction demolition and management (Jin *et al.*, 2019b) and construction safety (Jin *et al.*, 2019a). This study adopted VOSViewer for scientometric analysis in visualising, computing and analysing the influences of keywords, sources of documents and active regions in the field of CLP research. After the bibliometric and scientometric analysis, a qualitative discussion of existing research is presented. The research identified limitations in the existing studies and proposed directions for future studies.

3. Data analysis

3.1 Analysis of publication

The Scopus indexed articles published in the CLP research from 2012 to 2021 vary in number. In total, 24 articles published in 2013 were the minimum number of articles published within this period, while the maximum number of 67 articles were published in 2019. At the time of this report, conclusion cannot yet be drawn with regards the number of articles published in 2021. However, the present data reveal that more research articles, representing 61.7%, have been published in the past five years (2017–2021), with the possibility of recording more publications before the end of 2021. From 2016, publications in the CLP research field have recorded upward trajectory, which suggests that the interest of the research community has continued to rise in the research field.

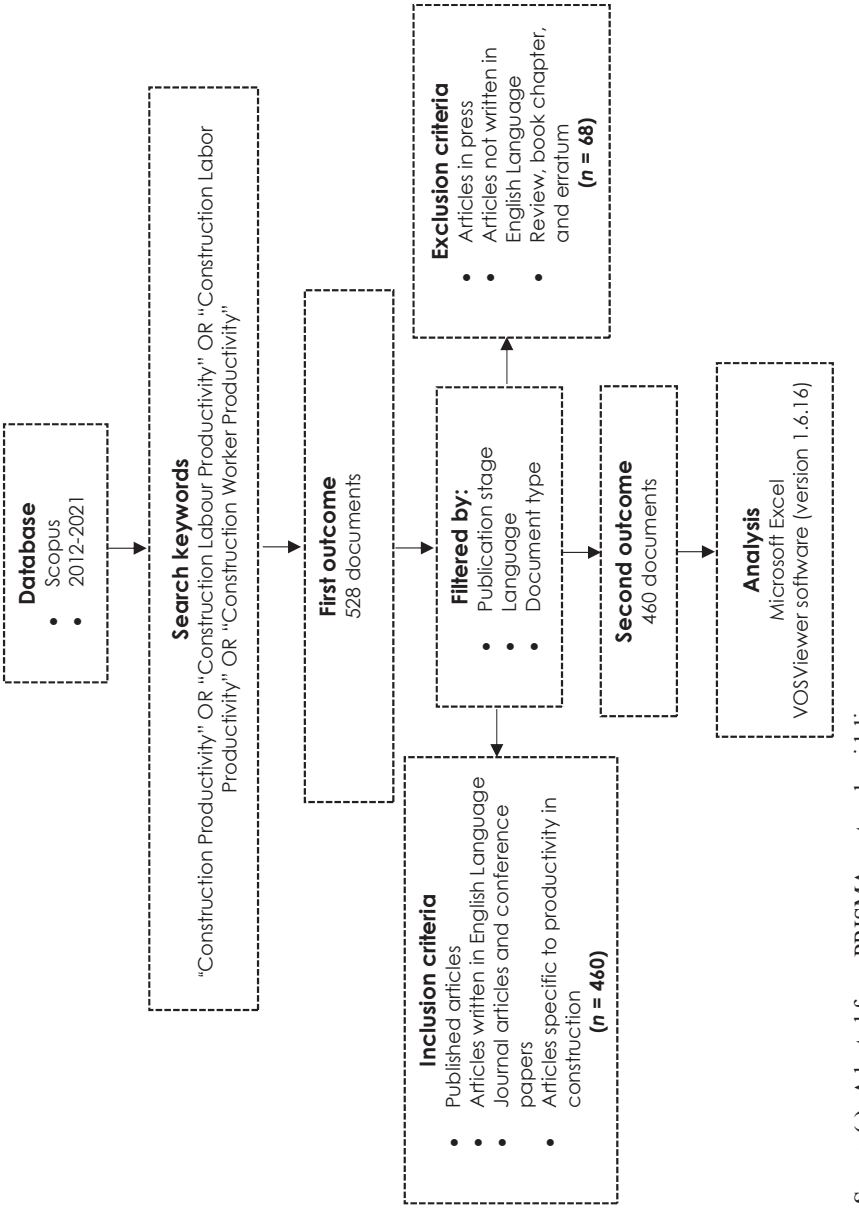

Figure 1.
Research process

3.2 Network of journal sources

The leading influential journals are presented in Figure 2. The influential journals were analysed and visualised using "citation-documents" bibliometric network in VOSViewer. For each of these journals, a minimum of ten research papers and 30 citations were set on VOSViewer for analysis. Consequently, eight sources met the threshold. The citation bibliometric network is shown in Figure 2. On the network, nodes represents journals, whereas the connecting lines between the journals indicate their citation relationships. The journals are separated into three clusters, which are indicated with different colours within the network. The first cluster indicates that the *Journal of Management in Engineering*, *Engineering Construction and Architectural Management*, and *Construction Management and Economics* have mutual citations. The second cluster reveal articles published in the *International Journal of Construction Management*, *Journal of Construction Engineering and Management*, and *Automation in Construction* as mutually cited articles. However, the distance of *Automation in Construction* indicates its weaker link with the *International Journal of Construction Management* and *Journal of Construction Engineering and Management*. The *International Journal of Productivity* and *Performance Management and Sustainability* (Switzerland) are the third cluster that explains their mutual citation. Size of font and journal nodes are clustered distinctively based on their number of published papers and citations (Vigneshkumar and Salve, 2020). Journals with high number of articles and citations are represented with larger node and font size (Van Eck and Waltman, 2014). The *Journal of Construction Engineering and Management* (33), *Engineering Construction and Architectural Management* (18) and *Construction Management and Economics* (14) are the three journals with more publications from 2012 to 2021 in the research field. The names of most journals are not fully presented in Figure 2 due to the limitation of using VOSViewer software for analysis. The names of these journals are mentioned in the test to compensate for the shortcoming.

3.3 Most active regions in the construction labour productivity research field

The regions that contributed most to CLP research were identified in VOSViewer. The minimum number of articles and citations of regions were set at 10 and 40, respectively. Among the 71 regions, where the CLP journal articles were spread, 14 regions met the threshold. Figure 3 presents visualisation of regions with regards to the findings of the regions' activity in CLP research. In the visualisation network, the node represents each region, while the size of the nodes indicates the number of articles that these regions contributed to the CLP research field. Based on the visualisation network, the USA achieved the most active region that contributed to the CLP research. Following the USA are Australia, Canada and India. The connecting lines between the regions indicate mutual citations of research works among the regions.

Table 1 presents the quantitative measurement of regions' and authors' influence in terms of their total publications, total citations and average citations (ACs). Although, Hong Kong recoded only 15 published articles, articles emanating from the region have an AC of 30.40, which makes the CLP publication from Hong Kong highly influential in terms of citation. Following Hong Kong are publications emanating from Iran (AC = 27.30), the USA (AC = 15.10) and Australia (AC = 13.94). An important conclusion that can be drawn from the available data is the significant contribution of the USA and Australia in terms of volume of publication and citation in the CLP research field.

3.4 Co-authorship analysis

Collaboration is common among academic researchers to exchange ideas and enhance their research productivity (Hosseini *et al.*, 2018). "Citation" and "Author" were used to create and visualise co-authorship bibliometric network (Figure 4). In VOSViewer application, minimum number of documents and citations for an author were set at 5 and 20, respectively. This will help to determinate the collaboration and citations of author's documents

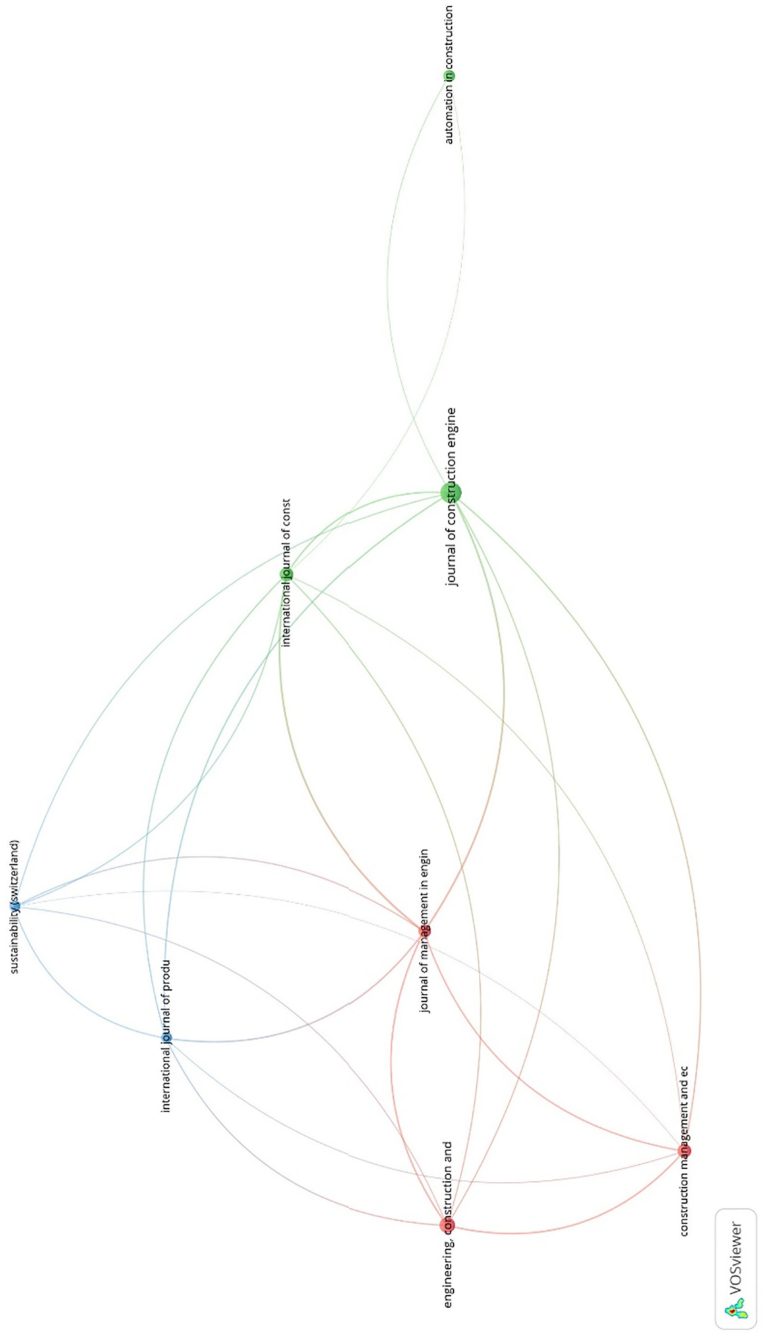

Figure 2.
Science mapping of most influential journals in the CLP research field

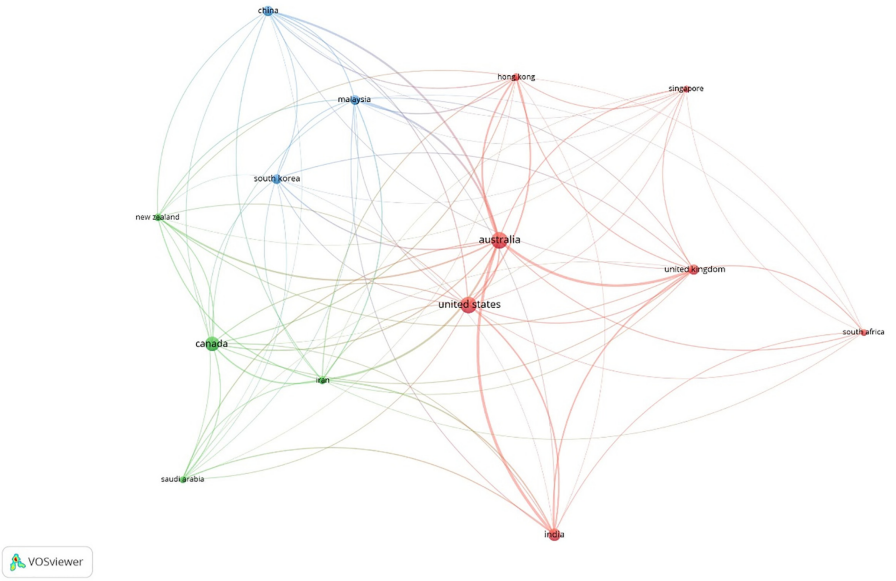

Figure 3.
Visualisation of regions active in CLP research

Region/Author	Total publication	Total citation	AC
USA	73	1,102	15.10
Goodrum P.M.	24	1,321	55.04
Australia	70	976	13.94
Haas C.T.	21	831	44.30
Canada	53	445	8.40
Liu C.	15	244	16.27
India	40	322	8.05
Gurmu A.T	14	123	8.79
UK	28	333	11.89
Caldas C.H.	12	589	49.08
China	28	258	9.21
Jarkas A.M.	10	322	32.20
South Korea	26	109	4.19
Fayek A.R.	10	243	24.30
Malaysia	25	122	4.88
Rojas E.M.	8	283	28.3
Iran	16	437	27.30
Durdyev S.	6	151	25.17
Hong Kong	15	456	30.40
Zhai D.	5	176	35.20

Table 1.
Most active regions and productive author in CLP research field

(Simpeh and Akinlolu, 2021). Among the 1,026 authors, ten authors met the threshold. Authors who are most influential in terms of their contributions to the CLP research domain are presented in Figure 4. Relative to Figure 4, there is visible collaboration between Goodrum P.M., Caldas C.H. and Zhai D., while collaboration between Fayek A.R. and Haas C.T. is also obvious. The bibliographic network further reveals collaboration among Haas C.T. Goodrum P.M., Caldas C.H. and Zhai D.

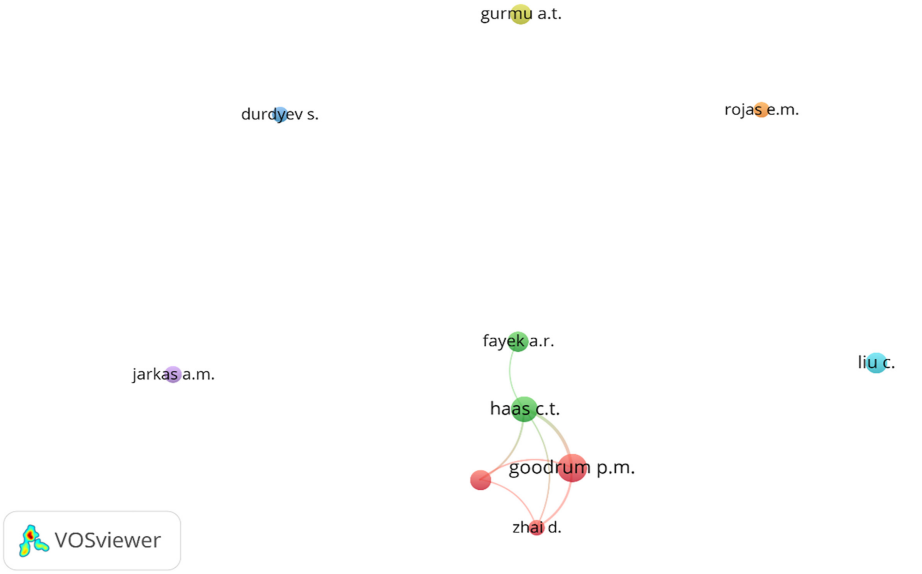

Figure 4.
Co-authorship bibliographic network

Based on the size of node in Figure 4 and number of documents published in Table 1, Goodrum P.M. having 24 published documents and 1,321 citations is the most productive author in the CLP research domain. Goodrum P.M. was not only the most productive in terms of the number of articles published but also the most influential in terms of AC. Following Goodrum P.M. in terms of quantity of articles published is Haas C.T. who had 21 articles, 831 citations and 44.30 ACs. However, Haas C.T. did not achieved the second most influential author in terms of AC. Caldas C.H. had higher AC of 49.08. Jarkas A.M., Fayek A.R. and Rojas E.M. are other authors who had significant influence in the CLP research community. It is essential to state that these ten authors have made notable contributions to CLP research projects; however, Goodrum P.M. and Haas C.T. have made the most remarkable knowledge contribution to the CLP research.

3.5 Author keywords co-occurrence

Key contents of published documents and the areas studied within a specific field are denoted by the keyword (Vigneshkumar and Salve, 2020). Different researchers might understand keywords differently; however, their co-occurrence with other keywords elucidates their meaning, especially when its usage occurs in many research papers (Isenberg *et al.*, 2016). The co-occurrence analysis forms the basis for deriving clusters and, therefore, research sub-fields. The inter-closeness among the keywords in Figure 5 emphasises its co-occurrence (Van Eck and Waltman, 2017; Vigneshkumar and Salve, 2020). Hosseini *et al.* (2018) recommended the use of "Author Keywords" in the analysis of VOSViewer, which is adopted in this study.

The minimum number of keyword occurrence was set as five. The network of 40 keywords that met the threshold is presented in Figure 5. Connection lines indicate the link between a pair of keywords (Akinlolu *et al.*, 2020a, b). The node colour expresses the cluster of keywords and divides keywords into several clusters, as expressed in the figure (Vigneshkumar and Salve, 2020). With the colour of the nodes, there are nine visible clusters, with each clusters containing keywords that have internal relationships with them. The keywords comprise emerging trends in the CLP research field. Keywords within the

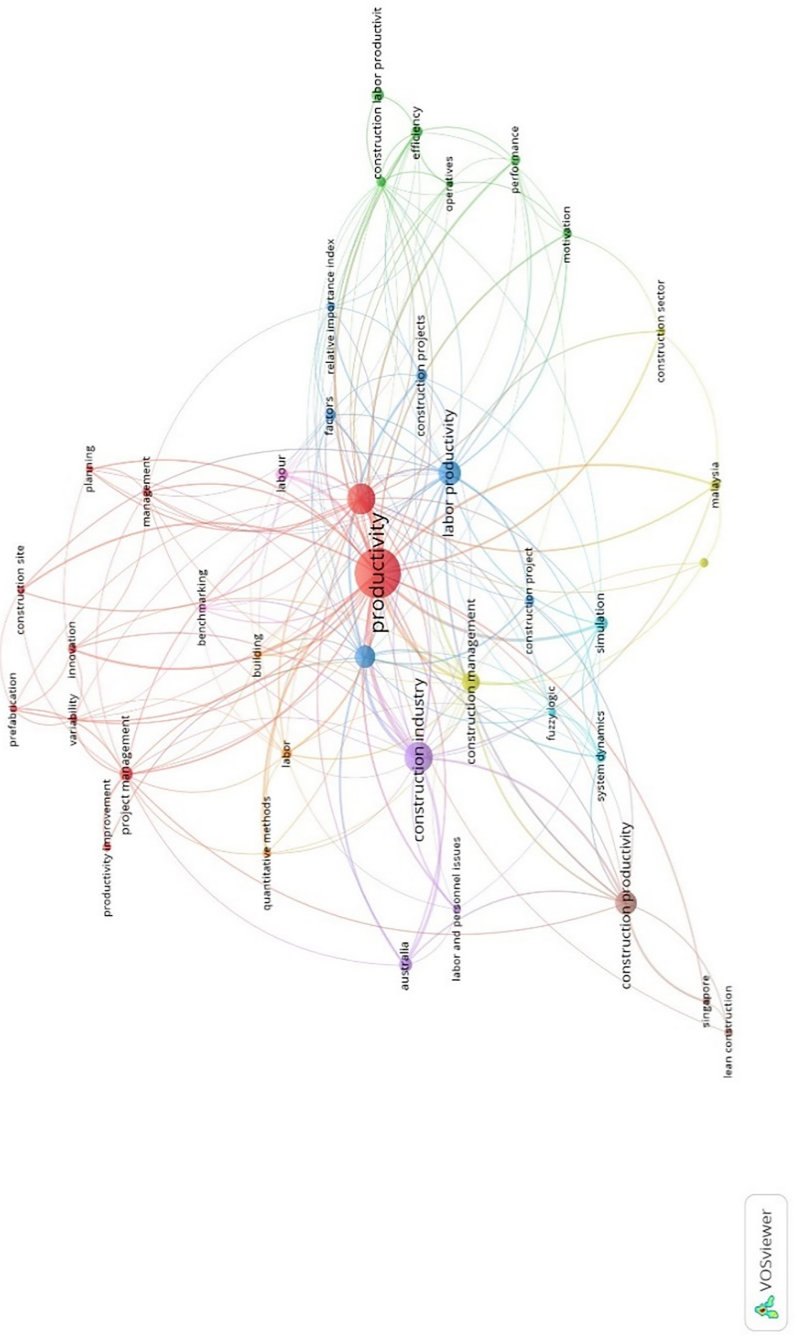

Figure 5.
Bibliometric network of co-occurring keywords

same cluster imply that internal relationships exist among the keywords. Some common keywords, which include productivity, construction, labour productivity, factors, building, construction project, were observed in the network. Given that the primary objective of this study is to obtain emerging knowledge areas in the CLP research field, these common keywords and others were excluded. Consequently, after their exclusion from the list, another analysis was conducted in VOSViewer (Figure 6). Drawing from the visualisation network, the network reveals three major clusters – (planning and management), (innovation, prefabrication, variability and benchmarking) and (operatives, efficiency, performance, motivation). Each cluster implies the keywords that are commonly considered in the same CLP research. These emerging knowledge areas are further examined in the discussion section. Similarly, total factor productivity, lean construction and labour and personnel are separately represented in the figure as some of the emerging discourses in the research field.

3.6 Publications with the highest impact

Publications with the highest impact in the past five years are presented in Table 2. The minimum number of citation of a document was set at 35. Among the 460 documents, 38 documents met the threshold. Thereafter, the documents published in the past five years were extracted from the list of publications, as represented in Table 2. The summary of each of the documents and their contributions are presented. De Soto *et al.* (2018) assess the impact of digital fabrication on productivity by analysing the cost and time required to build complex concrete walls for robots in the field to give the construction industry an incentive for further automation. The authors conducted a survey after defining different tasks for traditional concrete walls and robotic concrete walls. Data were collected from different sources and were used in simulations to describe the time and cost distribution for different construction scenarios. They concluded that productivity is higher when the robotic construction method is used for complex walls, indicating that it is possible to obtain significant economic benefit from the use of additive digital fabrication to construct complex structures. Hwang *et al.* (2017) identify the barriers to the development of green buildings, such as the high cost and project delay. Their study identify the critical factors affecting the productivity of green building construction projects by assessing the likelihood, impact and criticality of the factors with comparisons against traditional

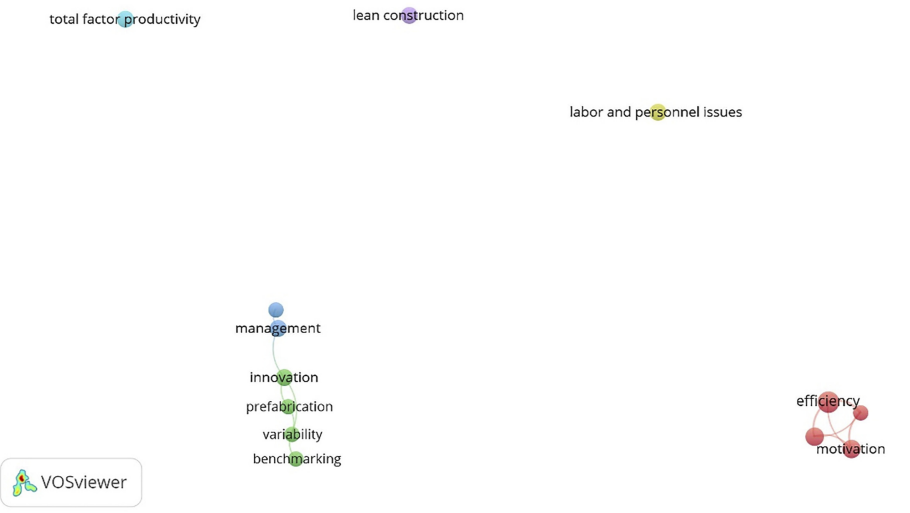

Figure 6.
Bibliometric network of co-occurring keywords after filtering

Author	Year	Title	Journal	Total citation
De Soto *et al.*	2018	Productivity of digital fabrication in construction: cost and time analysis of a robotically built wall	*Automation in Construction*, 92, 297–311	157
Hwang *et al.*	2017	Factors affecting productivity in green building projects: the case of Singapore	*Journal of Management in Engineering*, 33(3)	87
Alaghbari *et al.*	2019	Factors affecting construction labour productivity in Yemen	*International Journal of Construction Management*, 19(1), 79–91	85
Yi and Chan	2017	Effect of heat stress on construction labour productivity in Hong Kong: a case study of rebar workers	*International Journal of Environmental Research and Public Health* 14(19)	83
Hasan *et al.*	2018	Factors affecting construction labour productivity: a 30 years systematic review	*Engineering, Construction, and Architectural Management* 25(7), 916–937	81
Dixit *et al.*	2017	A study of enabling factors affecting construction productivity: Indian scenario	*International Journal of Civil Engineering and Technology*, 8(6), 741–758	55
Chen *et al.*	2020	Automated excavators activity recognition and productivity analysis from construction site surveillance videos	*Automation in construction*, 110	44

Table 2. Publications with the highest impact in the past five years

projects. Using a questionnaire survey to obtain data from professionals experienced in green building projects, the results indicated that workers' experience, technology, design changes, workers' skill level and planning and sequencing of work were the top five most critical factors affecting the productivity of green building construction projects. Alaghbari *et al.* (2019) identify factors affecting the CLP using a survey questionnaire. The authors categorised the factors into human/labour, management, technical and technological, and external. They concluded that technical and technological factors affect productivity more than human/labour, management and external groups. Their study provided awareness and a better understanding of factors affecting labour productivity in construction projects in Yemen. Excessive heat stress has profound effects on physiological responses, which cause occupational injuries, fatalities and low productivity. Construction workers are particularly affected by heat stress, because of the body heat production caused by physically demanding tasks, and hot and humid working conditions. Yi and Chan (2017) conducted field studies at two construction training grounds in Hong Kong, and labour productivity was measured and monitored. They concluded that onsite wet-bulb globe temperature, percentage of maximum heat rate, age, work duration and alcohol drinking habits were the determining factors for predicting the CLP. Hasan *et al.* (2018) reviewed 46 articles from different sources such as journals, conference proceedings and dissertations. The study found that despite noticeable differences in the socio-economic conditions across both developed and developing countries, an overall reasonable consensus exists on few significant factors impeding productivity. These are, namely, non-availability of materials, inadequate supervision, skill shortage, lack of proper tools and equipment and incomplete drawing and specifications. Using a structured questionnaire to obtain data from professionals working in the Indian construction industry, Dixit *et al.* (2017) studied the factors affecting the construction productivity and rank them on the basis of the responses given to their impact on the productivity of construction projects in India. The research identifies the top three factors having a significant impact on construction productivity as

decision-making, planning and logistics and supply chain management. In a recent study, Chen *et al.* (2020) propose a novel framework for automatically calculating and recognising the activity and productivity of multiple construction excavators. The framework, which was tested with a video recorded from real construction site, achieved 87.6% recognition accuracy and 83% productivity calculation accuracy.

4. Discussion

Higher productivity for contractors increases profit (Agrawal and Halder, 2020), while even a slight growth in their productivity can result in huge cost savings for the organisation (Nasir and Hadikusumo, 2018; Sookdeo, 2020). Lean construction eliminates waste in the construction process while maximising projects' productivity. Being one of the lean techniques, time studies are of utmost importance in terms of measuring productivity and construction project success. Regrettably, the construction industry is still confronted with time-related waste in the form of idle time and non-value-adding activities (Demirkesen *et al.*, 2020). Among the nine principles of the lean construction philosophy determined by Bajjou and Chafi (2018) include continuous improvement, elimination of waste, personnel participation, planning and scheduling. These principles correlate with productivity, and contractors can imbibe them for their organisations' total factor productivity improvement. More than other categories of factors affecting CLP in construction, labour and personnel issues are more notable. The issues include, but not limited to, poor workers' skills, absenteeism, poor workers' motivation, rework arising from incompetence, physical fatigue, problem of communication. Existing studies have advocated for the need for management to address the prevailing labour and personnel issues to promote projects, organisations and the industry's productivity growth.

During planning and execution of construction projects, project planners and managers make various assumptions with respect to execution of construction activities, availability of resources, suitability of construction methods and status of preceding activities. Ineffective project planning and design errors as the most crucial factors influencing productivity. High productivity is inherently linked to some latent factors, including planning and programming. Planning in construction is generally classified into pre-tender, pre-construction and construction planning. Contractors' ability to make adequate provisions in these planning phases is significant to their productivity during the production process. Management competence is key in achieving improved jobsite productivity. There is evidence to support the challenges associated with construction operations management in literature. Alaghbari *et al.* (2019) and Jarkas and Bitar (2012) express the need for contractors to address management-related issues to achieve productivity growth in construction. Although management-related challenges have continued to recur in CLP studies (Jalal and Shaor, 2019; Muhammad *et al.*, 2015; Mahamid, 2013; Parthasarathy *et al.*, 2007; Pornthepkasemsant and Charoenpornpattana, 2019; Thomas and Sudhakumar, 2013), contractors can still bring management flaws under control since they are largely internal causations (Abdelalim *et al.*, 2019; Alaghbari *et al.*, 2019). The universal changes in the business environment have begun to compel contractors to re-think their management styles for competitive advantage. The construction industry is one of the most dynamic industries; therefore, contractors must begin to transit from conventional management practices to strategic management practices. Through strategic management, it is essential for contractors to effectively utilise their organisations' multifactor resources. A few contractors are beginning to take advantage of strategic management process through environmental analysis and strategy formulation, while there are reports that these contractors perform better in project deliveries (Adendorff *et al.*, 2011). These contractors have learnt to analyse their internal and external business environments to correctly deploy their resources for a long-term CLP growth (Gurel and Tat, 2017).

Innovation, prefabrication, variability and benchmarking are essential emerging knowledge areas being investigated to improve productivity growth in construction. Innovative construction processes have recently been introduced into construction to boost productivity growth. An example is robotic fabrication techniques meant to enhance jobsite productivity considering the different levels of building complexity. Innovation will enable better result, as opposed to conventional construction processes (De Soto *et al.*, 2018). Digital fabrication, describing the link between digital technologies and the physical construction process. Digital fabrication techniques can increase productivity rates in the building industry not only because they lead to significant time saving for complex designs, but also because they exhibit the ability to transfer design data directly to 1:1 assembly operations and automated construction (De Soto *et al.*, 2018). Digital fabrication techniques are based on the combination of computational design methods and automated construction processes, which are typically categorised as subtractive, formative or additive. Onsite digital fabrication aims to bring additive fabrication processes on construction sites, while offsite digital fabrication aims to custom-design and prefabricate large-scale complex architectural elements offsite. Variability in productivity is a determinant of performance of a construction project. The initial stage in seeking for performance improvement involves the analysis of the extent of the process performance variability. This would reveal the extent of performance gap. Labour productivity, one of the key performance indicators in the construction industry, can be analysed to reveal the extent of performance gap. Poorly performing projects exhibit higher variability in productivity when compared to projects that perform well emphasised the necessity to reduce variability in labour productivity to improve performance of construction projects. Productivity is better understood as a quantity that varies not only over the duration of the activity, but also from one site to another. Labour productivity benchmarking models are used to understand the variability in productivity among different types of labour engaged in the construction projects. An understanding of its variability would provide an opportunity for managers to attain a leading edge in a competitive environment – the essence of benchmarking.

Moreover, operatives, efficiency, performance and motivation were found as some of the emerging discourses in the CLP research field. Despite the significant developments in construction technologies, operatives remain the key drivers in the industry. In most countries, construction labour cost comprises 30–50% of the overall project's cost, and thus ,it is regarded as a true reflection of the efficiency and success of the operation. The construction management literature has widely reported the significance of operatives' efficiency in driving productivity growth. The operatives are confronted with myriad of challenges in construction, which affect their efficiency attendant implication of an individual, project and organisation's productivity. Contractors must learn to keep efficiency of its team in mind all the time to sustain productivity gains. Odesola and Idoro (2014) and El-Sayegh (2008) advocate for good living conditions, timely wages and monetary incentive system as a strategy for performance improvement. Monetary incentives have been recognised as drivers of workers' effectiveness (Hafez *et al.*, 2014; Thomas and Sudhakumar (2013). Aina (2014) cautioned that project managers should understand the need of workers before adopting any motivation system as individuals' needs may vary considerably. Braglia *et al.* (2020) buttress that motivation is a personal characteristic, while their interdependence is hard to be evaluated and measured.

5. Limitations in existing research

Different methods have been used to explore CLP. A large number of the studies have achieved the primary objective of determining the salient factors that affects labour

productivity in construction. These factors have largely been obtained from literature, while investigations are further conducted to determine how essential each of the factors is to CLP. The existing studies have largely limited their enquiries into identifying factors affecting CLP, while some studies (Park, 2006; Zhan *et al.*, 2020) have further constructed frameworks with the salient CLP influencing factors. Productivity-influencing factors have been largely addressed without much consideration for the underlying causes of the identified factors. For example, Hwang *et al.* (2017), Alaghbari *et al.* (2019), Hai and Van Tam (2019), Jalal and Shoar (2019) and Karimi *et al.* (2017) identified skill shortage in construction, and further proposed interventions that could help improve skills in construction. However, the underlying causes of skill shortage and other salient productivity influencing factors are not investigated. This deeper level of investigation would contribute to proffering long-term productivity improvement measures and frameworks. Systems thinking is largely lacking in the CLP research (Zhan and Pan, 2020). Productivity-influencing factors do not occur in isolation (Dai *et al.*, 2009) but depend on one another. A systems thinking approach will holistically consider the issue and address CLP as a system. Besides, the CLP research domain has limitations in approach. Most of the research in the field has exclusively employed the quantitative research method to address factors affecting the CLP (Alinaitwe *et al.*, 2007; Construction Industry Development Board CIDB, 2015; Chan and Kaka, 2007; Dai *et al.*, 2009; Durdyev and Mbachu, 2011; Enshassi *et al.*, 2007; Jarkas *et al.*, 2015; Hiyassat *et al.*, 2016; Rivas *et al.*, 2011; Odesola and Idoro, 2014; Thomas and Sudhakumar, 2013). This sentiment is echoed by Alinaitwe *et al.* (2007) who state that surveys through questionnaires were found relatively easy to obtain standard data appropriate for achieving the objectives of productivity study. Certainly, a quantitative method is suitable to determine critical factors affecting CLP, exclusively adopting quantitative approach is unlikely to reveal the reality. Most studies have obtained factors affecting CLP from literature and request respondents to rate how the factors are applicable to their operations. Olomolaiye *et al.* (1987) note that factors affecting CLP differ from project to project and region to region. This suggests that a qualitative investigation is required to gather information that is relevant to specific project and region before quantitative data gathering should be considered. This will prevent recycling of the same factors obtained in the literature since the situation in different regions may differ significantly.

Advanced creative methodological tools such CLA have not been explored in promoting productivity in the construction industry, only limited studies (Pan *et al.*, 2019) have considered PESTEL model. The CLA is useful to deconstruct and reconstruct issues through different four layers. This would help in creating an alternative future for CLP improvement rather than the conventional methodological approach (Inayatullah, 2019). Some research works (Jarkas and Bitar, 2012; Nasirzadeh and Nojedehi, 2013; Durdyev and Ismail, 2016) have stated that technology is one of the essential factors to consider in improving labour productivity performance in construction. BIM as a multifaceted computer software data model that applies virtual and augmented reality technologies to visually present an architectural design have been gaining relevance to solve contemporary issues in construction (Chen *et al.*, 2019), such as construction safety improvement (Enshassi *et al.*, 2016; Lu *et al.*, 2021; Marefat *et al.*, 2019). BIM is a major innovation in the architecture, engineering and construction industry and has significantly improved building construction (Liu *et al.*, 2019). Despite the benefits of BIM, the existing studies in CLP have not explored these benefits to achieve the desired productivity improvement. BIM has become the focus of the practice and research of project, engineering and construction management (Durdyev and Mbachu, 2011); therefore, scholars in the CLP research domain should begin to investigate with digitisation, new technologies, sensors, advanced algorithms and other smart best practices to promote CLP growth.

6. Conclusions and future directions

This review-based investigation adopted a science mapping approach, which entails bibliometric search and scientometric analysis of 460 documents in the CLP research field. This investigation was limited to the Scopus database and journal articles published within ten years (2012–2021) in the CLP research field. The study considered the database because it contained a greater number of publications than the Web of Science database in construction fields. The Scopus database has been used by many researchers, which include Ahmad *et al.* (2021), Akinlolu *et al.* (2020a, b), Hosseini *et al.* (2018), Olawumi *et al.* (2018), Vigneshkumar and Salve (2020) and Yi and Chan (2014). Although this is a limitation to this study, further study can explore more databases to compare results. The study found that the most productive journals in terms of quantity of articles published were the *Journal of Construction Engineering and Management*, *Engineering Construction and Architectural Management*, and *Construction Management and Economics*. The study determined the most productive authors in terms of quantity of articles published as Goodrum P.M., Haas C.T and Liu C., whereas the most influential in terms of AC are Goodrum P.M., Celdas C.H. and Haas C.T. The USA, Australia and Canada were the most active regions according to quantity of publications, while the most influential regions based on AC were Hong Kong, Iran and the USA. Publications with the highest impact in CLP research based on total citation are *"Productivity of digital fabrication in construction: cost and time analysis of a robotically built wall"* authored by De Soto *et al.* (2018) and *"Factors affecting productivity in green building projects: the case of Singapore"* authored by Hwang *et al.* (2017). A recent publication, *"Factors affecting construction labour productivity in Yemen"*, authored by Alaghbari *et al.* (2019) achieved two less citations behind Hwang *et al.* (2017), which implies the high level of impact of the article. The study found lean construction, labour and personnel issue, total factor productivity, management, planning, operatives, efficiency, performance, motivation, innovation, fabrication, variability and benchmarking are the emerging knowledge areas in the CLP research field. A qualitative assessment of existing research was conducted to identify research limitations and further recommend future study directions. Based on the assessment, the directions for future research are, thus, recommended:

(1) Research work in the CLP field should not only identify factors that hamper productivity growth but also the underlying causes of the identified factors.

(2) Advanced creative methodological tools should be adopted to address labour productivity in construction. For example, the CLA is a useful analytical tool that can deconstruct and reconstruct CLP, which would allow an alternative future for CLP improvement to be created.

(3) Qualitative data gathering in the research area should always precede quantitative data collection.

(4) Technological tools such as BIM, virtual reality and augmented reality should be adopted to enhance CLP growth. These technologies have the potential to enhance elements of practice such as pre-project planning, identification of documentation errors and productivity monitoring using actual construction site data.

(5) Future studies should further explore the identified emerging knowledge areas in the CLP research field.

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