Mapping the knowledge domain of green procurement: a review and bibliometric analysis.

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Environment, Development and Sustainability
https://doi.org/10.1007/s10668-023-03948-w

REVIEW

Mapping the knowledge domain of green procurement: a review and bibliometric analysis

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Received: 4 September 2022 / Accepted: 18 September 2023

Abstract
The goal of green procurement, also called green purchasing, is to reduce waste and improve operational efficiencies to enhance sustainability. Although this practice has gained importance in recent years and garnered significant scholarly attention, there is a lack of bibliometric studies evaluating the green procurement field. To close this gap, we leverage bibliometrics to comprehensively summarize the literature and identify existing research hotspots and trends. Specifically, we employ bibliometric tools to analyze keywords, identify influential authors, universities, and research areas and reveal the most important publications in terms of citations. The analysis shows that sustainable development, sustainability, green supply chain management, and green public procurement are core topics related to green procurement. The co-citation analysis further reveals five important research clusters in the literature, namely green public procurement, green supply chain management, green supplier selection and evaluation of green performance, networked sustainable procurement, and green procurement in the construction sector. This study makes a contribution to the green procurement literature by summarizing this quickly growing field and providing timely guidance as to future research directions.

Keywords Green procurement · Sustainability · Green supply chain management · Waste · Bibliometrics

1 Introduction

Optimal supply chain performance and efficiency goals cannot be achieved unless all partners agree on procurement procedures which deliver high quality and value for money. In general, procurement is about securing goods, services, and works. It is defined as "*a multipart process, which includes vendor certification and selection, requisition preparation and approval, order placement, goods receipt, reconciliation and payment of the invoice, and order archiving*" (Robinson et al., 2005, p.34). Procurement is a key function in the supply chain, responsible for connecting supplier operations to downstream manufacturing and distribution tasks as well as verifying the quality of inputs (materials and services) (Forker et al., 1997). Conventional procurement essentially focuses on three important

Extended author information available on the last page of the article

criteria: quality, cost, and delivery (Ghosh, 2018). Besides these conventional criteria, green procurement also takes into account the environmental impacts (Cetin, 2020a; Zeren Cetin et al., 2020) resulting from supply chain management decisions (Yook et al., 2018; Zailani et al., 2012). Today, an increasing number of firms acknowledge environmental awareness as a critical business imperative since environmental initiatives have become a valuable source of competitive advantage (Hollos et al., 2012). The relevance of these practices has elevated interest in green procurement practices (Appolloni et al., 2014; Mendonça et al., 2021; Neto & Gama Caldas, 2018; Rafigh et al., 2021; Vejaratnam et al., 2020).

Green procurement seeks environmental sustainability by minimizing resource extraction and waste generation, motivating the reclamation and recycling of purchased materials without negatively impacting the performance requirements of such materials (Khan, 2019; Min & Galle, 2001). By minimizing energy consumption, resource use, and environmental pollution, green procurement strives to improve the efficiency of operations and, in turn, can enhance financial performance. Many firms have already incorporated environmental standards into their buying processes and implemented green procurement strategies, yet the majority has neither embraced a systematic approach to achieve the performance targets of green procurement nor linked green procurement with their overall organizational strategy (Song et al., 2017).

Since environmental awareness has become a business priority rather than an optional element, procurement managers are increasingly engaged in the quest to minimize negative environmental impacts (Cetin, 2016a) and develop sustainable business models (Awan, 2019; Awan & Sroufe, 2022). More than two decades ago, Porter and van der Linde (1995) note that procurement managers responsible for monitoring material flows into the firm are prompted to adopt resource reduction strategies. Similarly, Green et al. (1998) claim that as organizations are steadily transitioning toward sustainable environmental activities throughout their operations and supply chains, the conventional role of supply chain management is being rethought. This shift is facilitated by increasing opportunities for procurement managers to source more environmentally friendly materials with fewer risks to human health and the environment (Ahmed et al., 2021; Carter & Carter, 1998). AlNuaimi et al., (2021a, 2021b) posit that the implementation of green procurement in any firm is essential to attain higher environmental performance. Carter et al. (2000) recognize environmental initiatives and programs as a key dimension of social sustainability, highlighting that purchasing managers can generate value while significantly impacting environmental behaviors both within the organization and along its upstream supply chain. Despite these potentials, the application of green procurement practices is an exceedingly complex task hampered by a lack of the necessary knowledge, tools, and training among procurers and managers on the idea of lifecycle costs (AlNuaimi et al., 2021a, 2021b). Collaborating with stakeholders in the external environment is another great challenge for firms involved in greening practices, since other stakeholders might have different views on the necessity and requirements of green procurement (Song et al., 2017).

Given the prominence of green procurement research, several review studies have already been conducted on the topic. For example, Appolloni et al. (2014) investigated the key themes of green procurement in the private sector through a systematic review of articles published between 1996 and 2013 and suggested directions for future research. According to the authors, the literature on the adoption of green procurement revolved around three themes at that time: the motivations and drivers for implementing green procurement, the barriers to green procurement adoption, and the performance outcomes resulting from green procurement practices. Agyepong and Nhamo (2017) had a

focus on climate change and sustainable development and analyzed legislative provisions for green procurement in South Africa's metropolitan municipalities. Cheng et al. (2018) evaluated the literature related to green public procurement by analyzing academic papers published between 2000 and 2016. They found that the literature has focused mainly on the specific impact of green public procurement implementations while neglecting discussions concerning innovation and efficiency of environmental policy tools. Beer and Lemmer (2011) performed a critical review of green procurement in food supply chains and concluded that firms adopting green procurement and supply chain management practices can help to decrease pollution, improve water quality, and lower greenhouse gas (GHG) emissions. More recently, Vejaratnam et al. (2020) conducted a systematic review of 29 articles to identify barriers to the governmental adoption of green procurement. Their findings indicate that a lack of knowledge and awareness represent the major barriers to government green procurement, while financial constraints constitute a weaker impediment. Using a thorough literature analysis to summarize the drivers and obstacles identified in past research, Polonsky et al. (2022) investigate potential changes to the procurement process and determine the factors impacting the decision to buy products made from recycled or recovered materials. According to the authors, the public purchasing process can be improved through the development of green procurement standards, the establishment of internal organizational support, and information sharing both within the organization and with external bodies concerning alternative products containing recovered content or recycled materials. Sönnichsen and Clement (2020) present a survey of the literature on preliminary works involving green and sustainable public procurement from the year 2000 through 2020. The analysis demonstrates a need to understand the attributes of circular procurement in order to implement circular public procurement through the application of circular strategy and policy. The public procurer's beliefs and values become increasingly important in transitioning toward circular procurement, as the focus shifts from simply seeking the lowest price to identifying the optimal combination of timeliness, risk, and cost for the public institution based on a product's life cycle. In addition, Xu et al. (2022) analyze the current state of circular procurement in both the private and public sectors by examining the relevant works published between 1998 and 2021 across three main thematic areas: antecedents, practices, and outcomes. Finally, Qazi and Appolloni (2022) conduct an in-depth study of 100 scholarly articles on the topic of sustainable procurement and circular economy. Their review contributes to the literature by not only covering the literature from the top down, but also by discovering 55 enablers and barriers organized into several groups.

Even though these previous reviews contribute significantly to the green procurement literature, they are either outdated, limited in terms of the number of papers reviewed, or focused on a specific subset of green procurement (e.g., public or private or industry-specific procurement). Additionally, no prior reviews have used bibliometric methods to broadly examine green procurement research. Instead, extant studies have adopted either a systematic or conventional literature review approach and are therefore prone to subjectivity, bias, and incompleteness (Vijayakumar et al., 2018). Consequently, there remains an important knowledge gap regarding the current state of the entire field of green procurement, such as the identification of the major thematic areas in the green procurement literature, which can be addressed using bibliometric methods. Similarly, previous reviews have not applied co-citation analysis, which can help to uncover the history, foundation, and intellectual structure of the literature (Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e; Small, 1973). Therefore, there is value in conducting an up-to-date, comprehensive, and in-depth bibliometric analysis to offer novel insights

and advance the field. As opposed to conventional reviews which can be labor-intensive, biased, and inefficient for the analysis of larger literature bodies (Vijayakumar et al., 2018), bibliometric analyses enable researchers to arrange, synthesize, and quantitatively analyze the evolution of a topic using a large number of publications (Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e). As they are data-driven and can be used for the examination of a wide variety of textual materials (Patra & Mishra, 2006; Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e), the quantitative approach of bibliometrics guarantees an unbiased and impartial analysis of a scholarly area (Abdollahi et al., 2021).

To the best of our knowledge, no previous study has sought to comprehensively analyze the knowledge structure of green procurement research. To close this gap, the current study answers the following research questions (RQs):

- RQ1. What is the current status of green procurement research?
- RQ2. What are the main emerging themes or clusters in the green procurement field based on co-citation network analysis?
- RQ3. What are the important future research avenues or gaps that deserve attention from scholars studying green procurement?

We argue that the present study offers several valuable contributions to the current literature which go beyond those of previous works. First, we posit that green procurement research has evolved and warrants the application of quantitative review methods to better comprehend the intellectual base of this knowledge domain (Rivera & Pizam, 2015). As a growing research field, it is important to make sense of the substantial knowledge amassed in the green procurement literature by clustering and structuring the research, revealing key contributions, detecting research traditions and trends, and identifying future research directions (Ferreira et al., 2014). Even though the previous reviews add significantly to green procurement, the current literature is not appropriately theorized, and the methodological diversity in the available research is still limited. The literature also fails to provide a comprehensive overview of the many research areas and theoretical foundations that have been discussed. In this vein, scholars have stressed the need of uncovering and untangling the many intellectual traditions within this line of inquiry, as well as tracking the development of the field through time, in order to ensure the continued development of the subject as a whole. Consequently, the lack of a detailed overview of green procurement research is problematic because it prevents practitioners, scholars, and policymakers from gaining a comprehensive grasp of the green procurement domain, locate the information needed to solve pressing issues (e.g., climate change, pollution) (Bozdogan Sert et al., 2021; Cetin, 2016b, 2019, 2020b; Zeren Cetin & Sevik, 2020), track the field's development, and identify new opportunities. In light of this, there is a gap in the literature since no prior works have provided a comprehensive review of green procurement research taking into account both past and present research trends.

To fill these gaps, understanding both existing and rising research themes, guiding academics regarding research collaborations, and expanding the knowledge frontiers in the green procurement domain are all made easier by undertaking bibliometric and network analyses. To answer the research questions above, this review study is therefore guided by the following research objectives:

(1) To identify the key authors, institutions, and studies in terms of their contribution to the green procurement field

(2) To generate clusters and map the knowledge structure of related works in the green procurement field employing co-citation analysis
(3) To understand the temporal development of relationships between studies in the green procurement field
(4) To suggest future research directions based on the findings of previous academic literature

The rest of this review is structured as follows. Section 2 describes the methodology of the review and data collection. Section 3 summarizes and discusses the results of the study. Finally, Sect. 4 concludes the work and highlights implications, limitations, and future research directions.

2 Methodology

We performed several bibliometric analyses to thoroughly examine the field of green procurement. This quantitative approach aims to reveal the knowledge structure of a scientific domain (Arora et al., 2020) and identify its current status, hot topics, and future research directions (Kapoor et al., 2018; Mishra et al., 2018). A bibliometric analysis is based on mathematical methods and statistics to synthesize large datasets of extant literature to discover hidden research patterns and map the progress of the scientific field (Small, 1999; Tahai & Rigsby, 1998). By employing bibliometrics, we seek to cluster previous research endeavors based on their similarity using objective quantitative methods (Casillas & Acedo, 2007) to better understand the current research foci and paradigms that define the discipline (Thelwall, 2008) and discover novel insights. Several researchers have previously applied bibliometrics in related domains, including green supply chain management (Fahimnia et al., 2015; Gong et al., 2019; Martins, 2021), green finance (D. Zhang et al., 2019), green energy and environmental technologies (Tan et al., 2021), and green warehousing (Bartolini et al., 2019). In this section we first outline our approach and then describe the workings and goals of citation and co-citation analysis.

2.1 Data collection and analysis

As recommended by White and Griffith (1981), we carried out a comprehensive search of publications to cover the entire green procurement field, following five steps:

1. The initial step of data collection relied on the Scopus database: one of the most reliable and inclusive data sources with standardized results. Although several academic databases and online accessible sources can be consulted in bibliometric studies, the vast majority of technology-focused analyses use only a single database as a source (Suominen & Seppänen, 2014) due to the fact that the bibliometric software used (e.g., VOSviewer) can only read data from a single database and cannot treat or merge data from several databases (Yeung et al., 2019). As a result, and guided by several influential bibliometric analyses (Fahimnia et al., 2015; Mishra et al., 2017), we selected Scopus for the review due to its comprehensiveness and information breadth. Moreover, Scopus has a reputation for trustworthiness in indexing academic journals from prestigious publishers such as Springer, IEEE, Elsevier, Taylor and Francis, Wiley and Sons, and Emerald Insight (Foncubierta-Rodríguez et al., 2014). Scopus overlaps substantially with Web of

Science—84% of the publications indexed (Mongeon & Paul-Hus, 2016)—but indexes more academic journals in total (about 42,180) than the Web of Science database. Bibliographic meta data of publications related to green procurement were extracted, and the publications were screened to eliminate off-topic publications from the analysis.
2. In the second step, we identified the most critical keywords.
3. Applying citation analysis to uncover underlying citation patterns, we investigated the relationship between authors and publications. In addition, we revealed the most influential scholars and publications making outstanding contributions to the green procurement field.
4. We carried out a co-citation analysis to cluster similar articles into research communities.
5. Finally, we explored the linkages and relationships between countries, academic organizations, and journals to identify collaboration networks.

2.2 Formulation of appropriate search keywords

We used the following search strings for data collection: ("Green Procurement" OR "Green Purchas*" OR "Sustainable Procurement" OR "Sustainable Purchas*" OR "Ethical Procurement" OR "Environmental Procurement"). The keywords used were drawn from a preliminary screening of the literature and a review of seminal studies (i.e., systematic literature reviews) in the green procurement domain (Appolloni et al., 2014; Cheng et al., 2018). The search was performed in June 2022 in the Scopus database. Green procurement has several designations, including green purchasing, sustainable procurement, and environmental procurement (Appolloni et al., 2014). For the sake of transparency and clarity, the exact search query we used is shown in "Appendix 1." Undertaking a data curation process, we generated a text file that was later loaded into BibExcel, which is a free bibliometric toolbox for citation and co-citation analysis. This software package is highly compatible with other software (e.g., VOSviewer) and provides flexibility in data management and analysis. Additionally, we used VOSviewer version 1.6.1 to visualize the findings and create bibliometric networks. This tool provides a wide range of intuitive visualizations that assist in better understanding the findings, particularly for analyzing bibliometric networks. The first search results returned a total of 1129 publications. After the screening process, all irrelevant (i.e., off-topic), non-peer-reviewed, and non-English-language documents were excluded (Table 1), which resulted in the selection of 452 articles for the final analysis.

2.3 Citation analysis

Citation analysis provides various insights into a given knowledge domain (Sandison, 1989). First, this bibliometric tool helps to determine the impact of studies to identify the most influential scholars and studies contributing to the development of a scientific field (Gundolf & Filser, 2013). Second, knowledge patterns and communication linkages between scholars can be discovered. Third, by mapping out the linkages between citing and cited articles, one can better understand the evolution and transformation of the research field over time (Pournader et al., 2020). The underlying assumption is that if a publication receives a high citation count, it has likely made a significant contribution to the literature (Gundolf & Filser, 2013). Citation analysis of articles also aids in detecting important works and tracing the evolution of popular topics over time.

Table 1 Inclusion and exclusion criteria

Search string	"Green Procurement" OR "Green Purchas*" OR "Sustainable Procurement" OR "Sustainable Purchas*" OR "Ethical Procurement" OR "Environmental Procurement"
Database selection	Scopus
Search date	June 06, 2022
Inclusion criteria	• Articles focusing on green procurement in the private and public sectors • Articles published in English until December 2021 • Peer-reviewed journal articles were selected to ensure high-quality and certified knowledge (Ramos-Rodríguez & Ruíz-Navarro, 2004). This helps in strengthening the reliability of the findings and aligns with current practices in bibliometric analyses (Fahimnia et al., 2015; Fernandez-Alles & Ramos-Rodríguez, 2009; Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e)
Exclusion criteria	• Articles beyond industrial (organizational) procurement or studies focusing on consumer purchases • Articles published in 2022 were excluded since the year is incomplete • Chapters, books, conference proceedings, editorials, reports, notes, theses, and errata • Compared to journal articles, conference papers are not always peer-reviewed, might lack integrity and scientific quality, and can include preliminary findings and conclusions with the goal to obtain feedback from peers (Burton et al., 2021; Sadiq et al., 2022). As a result, they were not considered for the review

2.4 Document co-citation analysis

Co-citation analysis is a useful approach to examine relationships between articles and identify the intellectual structure of a research field (Nerur et al., 2008). By detecting the most cited articles and their linkages, this method classifies articles into different research clusters in which similar ideas are discussed (Small, 1973). It is important to point out that similarity does not necessarily indicate the concordance of articles' findings; instead, articles appear in the same cluster due to their topical similarity, regardless of whether their conclusions agree or contradict.

3 Findings and discussion

To begin, we analyzed the development of literature on green procurement. The annual distribution of publications is shown in Fig. 1. Given the pattern of temporal development, we divided the analysis into two different phases. We refer to the period between 1994 and 2010 as the introductory phase, with roughly four articles published yearly. We termed the post-2010 phase as the growth period, since research on green procurement witnessed a significant surge during this stage. This confirms a rising interest among researchers. Various authors have suggested that green procurement is increasingly acknowledged as an effective solution to address and reduce negative impacts pertaining to manufacturing and consumption worldwide (Brammer & Walker, 2011; Ho et al., 2010; Zhu et al., 2013) and the increasing number of publications beyond 2010 is consistent with this observation. In the remainder of this paper, we mostly focus our analysis on the growth phase because this period comprises the most recent and critical developments of green procurement.

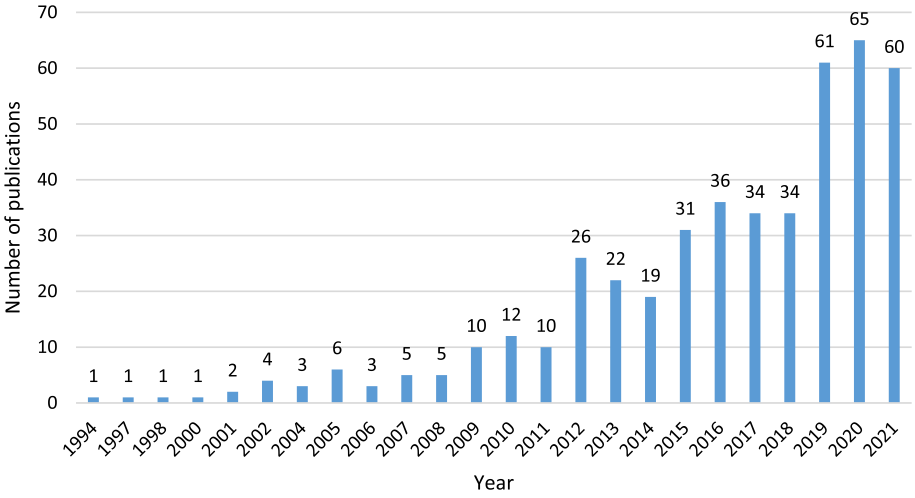

Fig. 1 Annual distribution of publications (Search date: June 06, 2022)

3.1 Keywords analysis

The keywords that researchers choose to represent an article have a significant influence on how the publication is received within academic communities. Keywords identify the key topics of the research and often determine an article's potential to succeed or fail (Kim et al., 2016; Uddin et al., 2015). As an approach to detect general research directions and trends, keyword analysis compiles the keywords of all related studies in a scientific field (Dixit & Jakhar, 2021). In the present study, we classified the extracted keywords into two groups (i.e., until the end of 2009 and 2010–2021) to analyze the most commonly discussed subjects. The top ten most frequently appearing terms in each time period are presented in Table 1. Furthermore, Fig. 2 depicts the keyword co-occurrence network for both time periods. We removed inconsistencies by merging all semantically equivalent keywords, like "GSCM" and "Green Supply Chain Management" or "Green Public Procurement" and "GPP."

From Table 2, it is obvious that "green procurement (GP)" constitutes a frequently used keyword in the two sets. Further, "sustainability" and "sustainable development" are prominent keywords in both phases. In the first period, "sustainable development" ranked fifth. McCrudden (2004) suggests that the emergence of green procurement holds the promise to promote the overall goal of sustainable development and the strong link between the two concepts evident in the literature is consistent with this notion. Green procurement contributes to sustainable development by offering innovative green products and services that deliver the economic, environmental, and social advantages sought by sustainable development (Walker & Brammer, 2012). According to Igarashi et al. (2013), the first green procurement initiatives appeared during the 1980s and 1990s, enticing firms to offer environmentally friendly products and services and actively contribute to sustainable development.

The high frequency of the keyword "sustainable procurement" in the second period as compared to the first indicates the devotion of scholars to investigating sustainable procurement as a strategically important approach to addressing sustainability issues (Aral et al., 2021; Brooks & Rich, 2016; Grandia, 2016; Hollos et al., 2012). Unlike green

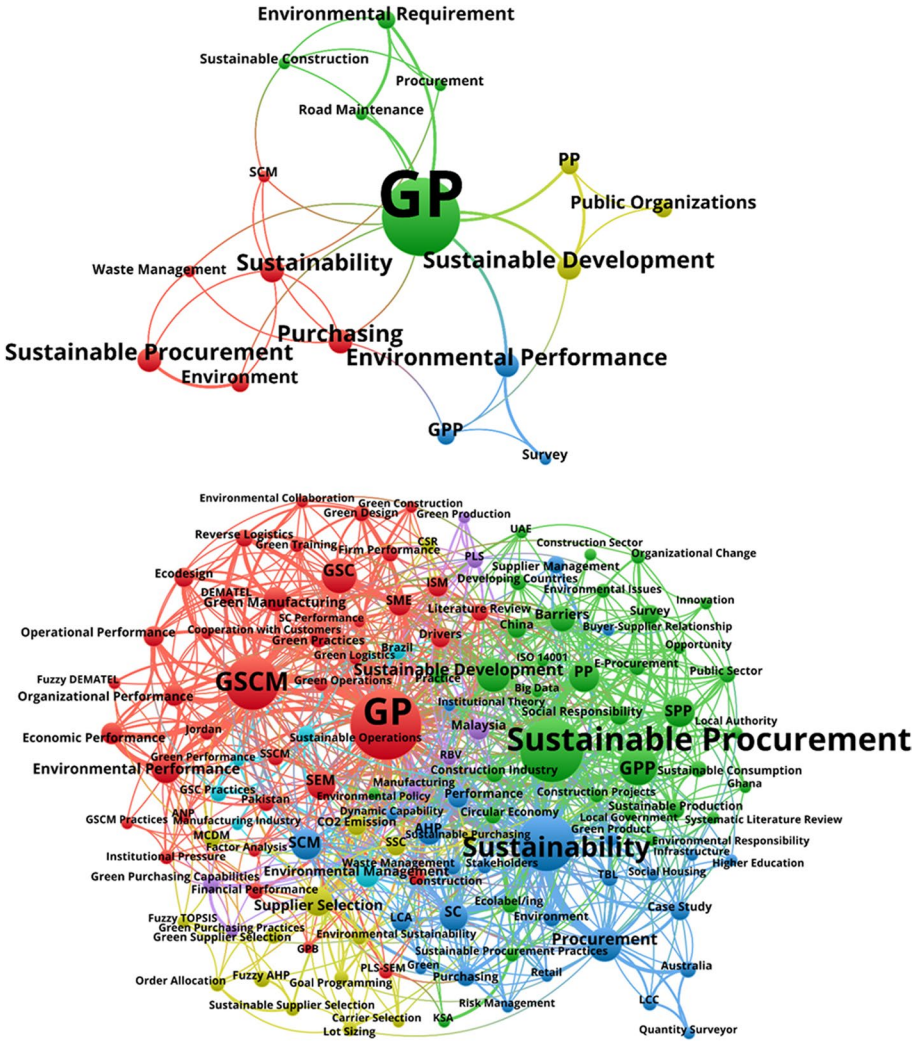

Fig. 2 Keyword co-occurrence networks for the periods 1994–2009 (upper part) and 2010–2021 (lower part)

procurement, which focuses solely on environmental procurement, sustainable procurement also considers the economic and social aspects of procurement (Cheng et al., 2018). In other words, sustainable procurement is viewed as a means for economic, environmental, and social objectives through the purchasing and supply process (Meehan & Bryde, 2014). According to Islam et al. (2017), practices of sustainable procurement may involve the reduction of packaging waste; the evaluation of the environmental performance of suppliers, labor rights, and safety records; the capacity to deliver eco-friendly products and the minimization of carbon emissions related to products' transportation. The occurrence of "green supply chain management (GSCM)" and "green supply chain (GSC)" in the second phase also underscores the importance of green procurement as a critical component of green supply chains (Khan & Qianli, 2017; Rane & Thakker, 2020). Generally,

Table 2 List of most frequently occurred keywords

Rank	1994–2009	2010–2021
1	Green Procurement (GP)	Green Procurement (GP)
2	Environmental Performance	Sustainable Procurement
3	Purchasing	Sustainability
4	Sustainability	Green Supply Chain Management (GSCM)
5	Sustainable Development	Green Public Procurement (GPP)
6	Sustainable Procurement	Green Supply Chain (GSC)
7	Environment	Sustainable Development
8	Environmental Requirement	Procurement
9	Green Public Procurement (GPP)	Public Procurement (PP)
10	Public Procurement (PP)	Supply Chain Management (SCM)

the greening of supply chain activities involves green procurement, which aims to extend green initiatives to upstream suppliers, thereby influencing the green supply chain through the acquisition of recyclable or reusable materials (Abdallah et al., 2012). It is also argued that the adoption of green procurement can lead to cost savings, increased environmental performance, quality improvement, and more efficient supply chain processes (Shen et al., 2017). In summary, green supply chain management has become an increasingly popular topic over the last recent decade due to rising environmental concerns, combative strategies, and worldwide awareness of environmental problems (Asif et al., 2020; Ilyas et al., 2020; Jum'a et al., 2022).

Finally, the frequency of the keywords "green public procurement (GPP)" and "public procurement (PP) is high in both periods. According to Bucea-Manea-Toniş et al. (2021a, 2021b), green public procurement evolved to become an effective tool for achieving the environmental policy goals articulated by the European Commission. The implementation of green public procurement aims to avoid or minimize the detrimental influence of consumption and production on the natural environment (Grandia, 2016). By leveraging public purchasing power to select green products and services, green public procurement can make a critical contribution toward sustainable development (Fet et al., 2011) and realize objectives related to climate change, efficient resource use, and sustainable production and consumption (Lundberg & Marklund, 2018). Furthermore, green public procurement can be used as an essential element of innovation policy and new models and strategies are leveraged in value creation through public procurement (Bucea-Manea-ţoniş et al., 2021). As a result, green public procurement represents a form of local government sustainability activity (Terman & Smith, 2018) that creates a competitive advantage (Bucea-Manea-ţoniş et al., 2021), reduces emissions (Leal et al., 2020), promotes eco-innovation (Testa et al., 2012), and drives sustainable production and consumption (Diófási & Valkó, 2014).

3.2 Influential authors

In a next step, we identified the most prominent authors and study how author citation networks structure the extant literature. We evaluate the citation structure of scholars who published at least one article on green procurement and reached a threshold of at least 150 citations in total. Out of 1110 authors, only 83 satisfy this condition. The temporal overlay of the authors with the highest citation counts is shown in Fig. 3, where

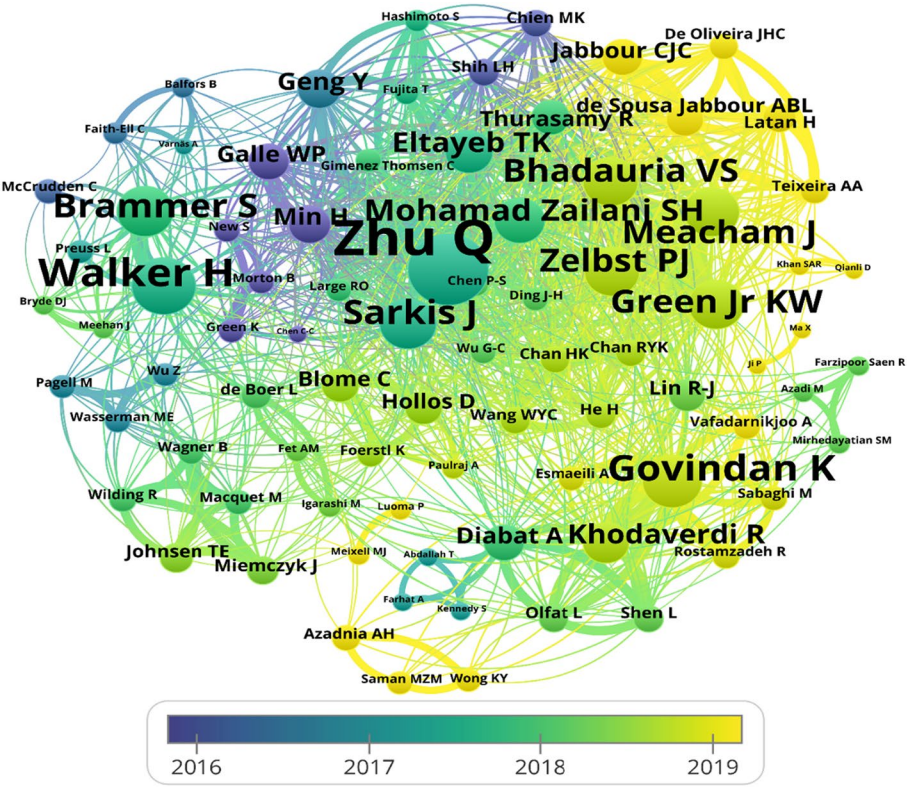

Fig. 3 Author citation analysis

the color scale indicates the annual evolution of the authors' citations. Table 3 shows the ten most influential authors, sorted by the maximum citation counts. Zhu Q. leads the list with 1333 citations, followed by Walker H. with 966 citations.

3.3 Citation analysis

The relevance and significance of a publication's contribution to the field is reflected in the number of times it is cited (Sharma et al., 2022). Citation analysis is therefore a core instrument for assessing an article's impact, despite its vulnerability to various biases, such as self-citation and citation bias (Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e; Sarli et al., 2010). Accordingly, we carried out a citation analysis to identify the most influential studies on green procurement. The list of the fifteen most cited studies for the periods 1994–2009 and 2010–2021 is shown in Table 4. The studies by Zhu and Sarkis (2007) and Min and Galle (2001) were the most cited during the earlier period, with 707 and 492 citations, respectively. In the context of the Chinese manufacturing industry, Zhu and Sarkis (2007) investigate the relationships between green supply chain management practices and environmental and economic performance, including the three moderating factors of market-, regulatory-, and competitive institutional pressures. The findings illustrate that Chinese manufacturers have witnessed mounting market and

Table 3 List of most cited authors

Rank	Author	Citations
1	Zhu Q	1333
2	Walker H	966
3	Govindan K	876
4	Sarkis J	799
5	Brammer S	797
6	Green Jr KW	756
7	Zelbst PJ	756
8	Meacham J	756
9	Bhadauria VS	756
10	Mohamad Zailani SH	696

regulatory pressures to improve environmental performance, particularly through the adoption of eco-design and green procurement practices. The paper from Min and Galle (2001) identifies the factors that either encourage or prevent the effective implementation of green purchasing and evaluates the impacts of green purchasing on the supplier selection, packaging, waste management, and regulatory compliance of the organization. The third most cited publication is a study by Chien and Shih (2007), which explores green supply chain management practices embraced by the electrical and electronic industry in Taiwan. According to the findings, Taiwanese electrical and electronic industry original equipment manufacturers (OEMs) have embraced green procurement and green manufacturing techniques in response to the present wave of worldwide green concerns, thus achieving positive environmental and financial outcomes.

In the second period from 2011 to 2021, the studies by Green et al. (2012) and Eltayeb et al. (2011) were the most highly cited publications. Green et al. (2012) theorize and empirically evaluate a comprehensive model based on green supply chain practices and performance. Their model integrates green supply chain practices that connect manufacturers with supply chain partners to foster environmental sustainability throughout the supply chain. Their findings illustrate that the implementation of such practices by manufacturing firms results in enhanced environmental performance and economic performance, thereby positively impacting operational performance. Additionally, the authors highlight the critical role of internal environmental management and green information systems in implementing green procurement cooperation with customers, eco-design, and investment recovery. Importantly, this study was the first to propose and empirically assess a comprehensive green performance model related to supply chain management practices, thus clarifying the synergistic effect of such practices on organizational performance.

The second most cited paper from Eltayeb et al. (2011) evaluates the potential environmental, economic, and intangible impacts of green supply chain activities. By collecting answers from 569 ISO 14001 certified companies in Malaysia, the findings of this survey study show that anticipated green supply chain activities have a favorable impact on environmental and economic outcomes, cost reductions, and intangible outcomes. Further, reverse logistics is shown to exert a significant influence on cost reductions. Consequently, firms can reap financial and operational advantages by designing and producing sustainable products and recycling their packages, while also protecting the environment through minimum waste generation and improved resource utilization.

Among the remaining fifteen most cited studies between 2010 and 2021, we observed a strong focus on research associated with green supply chain management practices

Table 4 List of most cited papers

Rank	1994–2009		2010–2021	
	Document	Citations	Document	Citations
1	Zhu and Sarkis (2007)	707	Green et al. (2012)	756
2	Min and Galle (2001)	492	Eltayeb et al. (2011)	461
3	Chien and Shih (2007)	314	Lin (2013b)	415
4	Walker and Brammer (2009)	302	Brammer and Walker (2011)	334
5	McCrudden (2004)	267	Shen et al. (2013)	325
6	Green et al. (1998)	246	Chan et al. (2012)	309
7	Preuss (2009)	193	Govindan et al. (2015a)	282
8	Chen (2005)	151	Wilding et al. (2012)	275
9	Varnäs et al. (2009)	145	Rostamzadeh et al. (2015)	269
10	Ofori (2000)	144	Wu et al. (2012)	251
11	Zhu and Geng (2001)	131	Pagell et al. (2010)	250
12	Michelsen and de Boer (2009)	106	Hollos et al. (2012)	246
13	Huang et al. (2006)	95	Azadnia et al. (2015)	243
14	Thomson and Jackson (2007)	94	Large and Gimenez Thomsen (2011)	243
15	Walker and Phillips (2009)	86	Zhu et al. (2010)	226

(Eltayeb et al., 2011; Lin, 2013a; Rostamzadeh et al., 2015), sustainable supplier evaluation and selection (Azadnia et al., 2015; Hollos et al., 2012; Shen et al., 2013), and green public procurement (Brammer & Walker, 2011). In the early years, researchers focused more on empirically investigating the impact of green supply chain initiatives on firm performance as well as the conceptualization and measurement of sustainable purchasing and supply chain management, while more recent research focuses on evaluating and establishing green practices and performances.

In summary, our citation analysis reveals that the most influential studies have undertaken empirical investigations to assess green supply chain management practices, including those related to green procurement. Interestingly, we did not find highly cited studies that apply qualitative methodologies or descriptive case studies, which represents an important knowledge gap and calls for additional research on green procurement using these approaches.

3.4 Co-citation analysis

The widely used bibliometric technique of co-citation analysis seeks to determine similarity between articles and to group them accordingly (Gmür, 2006). A thorough investigation of a cluster can uncover research topics common to several articles. In this sense, Small (1973) suggested using co-citation analysis to examine the most significant and foundational publications within a knowledge domain. We examine the co-citation structure of the literature regarding green procurement to identify knowledge patterns among articles and illustrate relations between subject areas. To restrict the collection to the most influential publications (Goyal & Kumar, 2021), we set a co-citation threshold which allowed inclusion only if the two publications had been co-cited in the bibliographies of at least of 20 separate articles. Furthermore, we clustered the studies based on their conceptual

similarities and intellectual structure which resulted in the emergence of five clusters. The upcoming sections discuss the findings of the clusters, with the seminal articles from each cluster listed in Table 5.

3.4.1 Green public procurement

This cluster contains twenty-six articles, of which the ten most cited are presented in Table 5. The publications in this cluster discuss green procurement in the public sector, which is expected to support environmental policy goals associated with resource use, climate change, and sustainable production and consumption. Preuss (2009) argues that local government authorities can use their procurement functions to promote sustainable development. This can be achieved by motivating first-tier suppliers to involve small local businesses as their subcontractors, contracting with voluntary organizations, or replacing harmful materials in products and services. McCrudden (2004) notes that governments can make use of contracts to generate desired social policy outcomes through public procurement. In other words, governments can leverage their purchasing power to achieve environmental and social policy objectives. Committing to public green procurement fosters markets for sustainable services and products, giving suppliers the opportunity to reduce their environmental impacts (Thomson & Jackson, 2007). The relationship between sustainable procurement and the public sector is also examined by Walker and Brammer (2009), who specifically measure "purchasing social responsibility." The findings of their study reveal that there is substantial variation across public sector agencies when it comes to sustainable procurement practices. They also find that the implementation of sustainable procurement in the public sector is facilitated by top management support yet hampered by cost. Further, the study by Walker and Brammer (2012) surveys sustainable procurement practices among 283 public procurement managers from 20 nations and finds that leadership is a significant enabler for sustainable public procurement. However, financial issues remain the most important barrier to sustainable procurement, with public sector procurers being hesitant to pay more to purchase sustainably. In addition, Walker and Brammer (2012) studied the relationship between e-procurement and sustainability in two public procurement initiatives and demonstrated that e-procurement and collaboration with suppliers is a key facilitator for sustainable public procurement. Finally, potential research pathways for this cluster include researching the innovative capabilities and information technology (IT) infrastructure necessary to develop innovative modes of green public procurement (Al Nuaimi et al., 2020). While the literature has mainly focused on external forces that influence the implementation of green public procurement, internal forces also need to be explored in detail (Vluggen et al., 2019), as the interaction between the external and internal forces ultimately determines the greenness of public procurement practices (Gelderman et al., 2017). Additional research on the cultural dimensions of green public procurement is imperative to overcome pressing sustainability issues (Delmonico et al., 2018). Researchers also need to explain the influence of green public procurement on economic systems and investigate whether this practice leads firms and supply chains to foster sustainable development and environmental innovation. Additional studies on the impact of governance, collaboration and innovation on green public procurement are also needed (Awan & Sroufe, 2020; Awan et al., 2018).

Table 5 Clustering of most relevant publications in green procurement

Cluster	Broad theme	Works
1 ($n=26$)	Green public procurement	Brammer and Walker (2011), McCrudden (2004), Meehan and Bryde (2011), Michelsen and de Boer (2009), Preuss (2009), Testa et al. (2012), Thomson and Jackson (2007), Varnäs et al. (2009), Walker and Brammer (2009, 2012)
2 ($n=24$)	Green supply chain management (GSCM)	Chan et al. (2012), Chien and Shih (2007), Eltayeb et al. (2011), Green et al. (2012), Green et al. (1998), Hollos et al. (2012), Large and Gimenez Thomsen (2011), Min and Galle (2001), Wu et al. (2012), Zhu and Sarkis (2007)
3 ($n=11$)	Green supplier selection and evaluation of green performance	Azadnia et al. (2015), Govindan et al. (2015a), Igarashi et al. (2013), Lin (2013b), Mirhedayatian et al. (2014), Rostamzadeh et al. (2015), Shen et al. (2013), Uygun and Dede (2016), Wu and Chang (2015b), Zhao and Guo (2014)
4 ($n=3$)	Networked sustainable procurement	Crespin-Mazet and Dontenwill (2012), Pagell et al. (2010), Wilding et al. (2012)
5 ($n=3$)	Green procurement in the construction sector	Bohari et al. (2017), Shen et al. (2017), Wong et al. (2016)

3.4.2 Green supply chain management (GSCM)

The articles in this cluster focus on numerous aspects of green supply chain management. Related to green purchasing, Green et al. (1998) study the impact of this practice on the environmental performance of organizations in a supply chain network and conclude that a collaborative partnership is not necessarily the most effective solution for environmental sustainability. Hollos et al. (2012) also find that sustainable supplier cooperation has overall positive impacts on firm performance across environmental, social, and economic dimensions. The drivers of green supply chain management practices are also examined in different geographic contexts. For example, Min and Galle (2001) conducted a survey of US companies with higher environmental risks and deduce that large companies require their suppliers' environmental commitment as an element of supplier quality assurance because of their greater bargaining power. In Germany, Large and Gimenez Thomsen (2011) investigated green supply chain management capabilities, the strategic level of the purchasing department, the level of environmental commitment, the degree of supplier assessment, and the degree of green collaboration with suppliers to develop a structural model explaining environmental performance and purchasing performance. Their findings suggest that the degree of green supplier assessment and the level of green collaboration directly impact environmental outcomes. Zhu and Geng (2013) reveal that Chinese manufacturers adopt extended supply chain practices for Energy Saving and Emission Reduction (ESER) goals, albeit at a low level. Eltayeb et al. (2011) evaluated the actual environmental, economic, and intangible implications resulting from the implementation of green supply chain initiatives using a sample of 569 ISO 14001 certified companies in Malaysia. The green supply chain practice of eco-design exerts a positive influence on environmental, economic, cost-related, and intangible outcomes, whereas reverse logistics is found only to yield cost reductions, and green purchasing has only a marginal impact on any of the performance outcomes. The firm's responsiveness to the adoption of green supply chain management practices is influenced by growing institutional pressures, forcing firms to adjust their conventional supply chains to offer more sustainable products. In this regard, Zhu and Sarkis (2007) investigated the relationships between green supply chain management practices and environmental and economic performance, including market, regulatory, and competitive institutional pressures as moderating variables. The results indicate that Chinese firms witnessed growing environmental pressure to adopt green supply chain management practices. The higher regulatory pressures also tended to force manufacturers to adopt green purchasing practices. Wu et al. (2012) also studied the moderating impacts of institutional market, regulatory, and competitive pressures and discovered that green purchasing is positively influenced by organizational support, social capital, and government involvement.

Related to this cluster, additional research is needed to better understand how green supply chain implementation translates into tangible outcomes, as compared to supply chains that simply claim to follow green practices. In addition, there is a need to study the impact of green supply chain practices on green procurement, especially when different actors are involved in procurement processes (Alberg Mosgaard, 2015). The connection between green procurement and green supply chain efficiency, transparency, competitiveness, and operational excellence also needs to be studied and tested in future research (Islam & Alharthi, 2020). Such insights will help to clarify the contributions of green procurement to the development of effective and efficient green supply chains.

3.4.3 Green supplier selection and evaluation of green performance

The third cluster discusses the topic of green supplier selection and evaluates green supply chain management practices using diverse techniques of multi-criteria decision-making. Regarding green supplier selection, Azadnia et al. (2015) suggest an integrated mathematical model for sustainable supplier selection and order allocation coupled with multi-period product lot-sizing problems, highlighting the importance of social, environmental, and economic qualitative criteria for supplier selection. Shen et al. (2013) propose a fuzzy multi-criteria approach for green supplier assessments and show that environmental performance plays a key role in supporting green supplier selection. To incorporate sustainability into the supplier selection modeling area, Dai and Blackhurst (2012) propose an integrated analytical approach based on the analytical hierarchy process (AHP) and quality function deployment. They conclude that the performance outcomes of green procurement can yield effective sustainability policies and higher customer satisfaction. Finally, a study by Igarashi et al. (2013) summarizes the literature surrounding green supplier selection and identifies the prevalence of analytical research to develop normative decision models for the last stage in green supplier selection, while empirical studies on this topic remain scarce and without a clear theoretical background.

The remaining studies in this cluster apply various modeling techniques to examine green supply management practices. For example, Govindan et al., (2015a, 2015b) and Lin (2013a, 2013b) use a fuzzy-based DEMATEL to evaluate green supply chain practices. In the first study, internal management support, green purchasing, and ISO 14001 certifications are identified as the most important green supply chain practices. Lin (2013a, 2013b) recommends that managers place more attention on four factors in green supply chain management, namely recovery and reuse of used products, regulation, pressures from stakeholders, and environmental performance. Wu and Chang (2015a, 2015b) demonstrate that adopting green purchasing represents one of the most important factors in supplier management. Through the application of fuzzy VIKOR, Rostamzadeh et al. (2015) find that an environmental audit of suppliers' internal management is the most important criterion used for green purchasing. Concerning future research directions, not only the economic and environmental dimensions of sustainability should be considered for supplier selection, but also its social dimensions (e.g., child labor, human rights abuse, irresponsible investments) need to be incorporated into supplier selection (Ghadimi et al., 2016). The advantages of green supplier selection have only rarely been investigated from a firm perspective, thus future research needs to quantify sustainability performance related to supplier selection. This is crucial to achieve carbon savings and maximize operational efficiencies. Investigating joint collaborative mechanisms with green suppliers is another research direction that deserves more attention since green supplier development and mentoring can enhance the overall performance of green supply chain management.

3.4.4 Networked sustainable procurement

The fourth cluster contains only three articles that revolve around sustainable procurement from a network perspective. For example, Crespin-Mazet and Dontenwill (2012) stress the importance of the network approach to overcome sustainable procurement challenges. According to the authors, organizations with a sustainable development strategy can achieve legitimacy by not only involving direct and indirect suppliers in the organization's

value creation processes but also non-business stakeholders, including technical experts, labeling organizations, the government, ecological foundations, the media, and the regulatory and standardization agencies. Moreover, Pagell et al. (2010) reveal that the conventional purchasing portfolio matrix introduced by Kraljic is not effective in the field of sustainable supply chain management. The authors agree on the necessity to make an investment in supplier continuity to ensure that supply chain partners stay in business, thrive, prosper, and grow. Finally, Wilding et al. (2012) conduct a structured review of purchasing and supply management, going beyond the typical environmental and social sustainability. Two different trends are reported; firstly, internal or dyadic challenges are prioritized, and secondly, environmental sustainability is prioritized above social sustainability. Related to the cluster, future research may examine how purchasers can develop new dynamic capabilities, processes, and entrepreneurial modes of sourcing to cope with the dynamically changing environment and evolve towards a genuinely sustainable supply chain (Crespin-Mazet & Dontenwill, 2012). The role of networked sustainable procurement in increasing the performance of downstream and upstream actors has to be clarified (Engelseth et al., 2021). Researchers also should adopt a network approach to investigate the importance of procurement consortia in delivering sustainable procurement (Meehan & Bryde, 2015).

3.4.5 Green procurement in the construction sector

The final cluster contains three articles that focus on green procurement in the construction sector. For example, Bohari et al. (2017) report the findings of green procurement activities in Malaysia on the basis of literature analysis and pilot research using semi-structured interviews of qualified professionals. Despite the fact that green procurement is not widely used across construction stakeholders, certain green procurement practices are evolving in the sector, including the presence of green procurement rules and the incorporation of green criteria into the bidding process. In the context of Hong Kong, Wong et al. (2016) offer insight into the variables that are significant in boosting green procurement in the construction process and propose suggestions for the successful implementation of green procurement. Through a questionnaire survey and expert interviews, governmental regulations and standards for green procurement are revealed as the most significant factor, followed by lifecycle considerations and green construction technology, as well as the commitment of executive management. Furthermore, the study identifies that in the green procurement process, efforts, or activities performed by the government and the community such as awards, competitions, incentive programs, and green procurement commitments and requirements of executives are deemed essential. Finally, Shen et al. (2017) explore the green aspects of green building materials (GBM), variables impacting green procurement practices, and green procurement behavior in real estate development. The findings indicate that the primary variables comprise marketing benefits, market pressure, and internal pressure within the firm, with policy pressure, marketing benefits, and business benefits being the most common reasons for developers to implement green procurement. Overall, this cluster shows that the implementation of green procurement in the construction sector remains a challenging task. As a result, future studies should develop organizational models for the implementation of green procurement in the construction sector. This would help top managers and decision-makers to grasp the adoption decision process and better prioritize the factors affecting sustainable procurement adoption in construction (Agbesi et al., 2018). In addition, researchers should quantify the factors

contributing to green procurement adoption in developing countries, where the construction sector is progressing and has a significant impact on economic development (Khahro et al., 2021; Ogunsanya et al., 2021). The role of Industry 4.0 technologies in accelerating the implementation of green procurement in construction projects is another highly interesting research area deserving further attention.

3.4.6 Most relevant countries and universities

The final phase of our study includes the examination of the country of origin and the affiliations of the authors. The analysis of most relevant countries and academic institutions aims to identify the geographic distribution of researchers contributing to green procurement. The diversity of nations and universities engaged in green procurement research is noteworthy. From a national perspective, the UK, China, India, and Malaysia rank at the top of the list according to number of publications (see Table 6). The existing research on green procurement is largely concentrated in Asian countries, mainly due to their commitment to sustainable development and economic growth (Deshpande et al., 2020; Joshi & Rahman, 2016; Lee, 2017). For example, in China, the green sectors contribute to a significant reduction of industrial pollution and sustain the economic development of the country (Fraccascia et al., 2018). Over recent years China has become the largest carbon emitter globally, which led to increasing pressure for the Chinese policymakers to reduce emissions and improve manufacturers' competitive advantage (Tian et al., 2016). Having

Table 6 Countries and academic institutions contributing to green procurement literature

Rank	Top countries
1	UK
2	China
3	India
4	Malaysia
5	USA
6	Australia
7	Sweden
8	Brazil
9	France
10	Indonesia
Rank	Top universities
1	Universiti Teknologi MARA, Malaysia
2	Universiti Sains Malaysia, Malaysia
3	Norges Teknisk-Naturvitenskapelige Universitet, Norway
4	Universiti Malaya, Malaysia
5	The Royal Institute of Technology KTH, Sweden
6	University of Warwick, UK
7	King Abdulaziz University, Saudi Arabia
8	Universidade Estadual Paulista Júlio de Mesquita Filho, Brazil
9	Hong Kong Polytechnic University, Hong Kong
10	Indian Institute of Technology Delhi, India

the world's second largest population with fast industrialization and worsening environmental degradation, India has led many initiatives in collaboration with external agencies to enhance material productivity and reduce waste (Kamble et al., 2021). The country also acknowledged the importance of environmentalism and green consumption (Uddin & Khan, 2018). The Indian government spends nearly 21% of GDP per year on procurement, which acts as a vehicle for implementing sustainable procurement practices (Saroha et al., 2019).

From the perspective of academic institutions, Universiti Teknologi MARA, Malaysia, tops the list in terms of articles published, followed by Universiti Sains Malaysia, and Norges Teknisk-Naturvitenskapelige Universitet, Norway. Universiti Teknologi MARA is represented by the authors Asmah Alia Mohamad Bohari and Zafikha Aida Bidin; Suhaiza Zailani and Eltayeb Tarig Khidir represent Universiti Sains Malaysia; and Norges Teknisk-Naturvitenskapelige Universitet is represented by Ottar Michelsen. From Europe, the list includes academic institutions such as the University of Warwick from the UK. The universities with the highest number of articles and their academic networks are shown in Fig. 4.

Additionally, we investigate the main academic journals in the field as well as journal clusters. Table 6 shows that *Journal of Cleaner Production* ranks at the top with 51 published papers, followed by *Sustainability* with 25 papers. Both journals focus on environmental, clean production, and sustainability research. Supply chain management-related journals such *International Journal of Supply Chain Management* (15 papers) and the *Journal of Purchasing and Supply Management* are also premier journals in the procurement field. Overall, the top ten journals have contributed 150 academic articles to the literature, which is nearly 23% of all published papers. Table 7 displays the top ten outlets that have published on green procurement.

The analysis of journal co-citations allows us to investigate the relevance and similarity between articles. The journal co-citation analysis results in two clusters, as

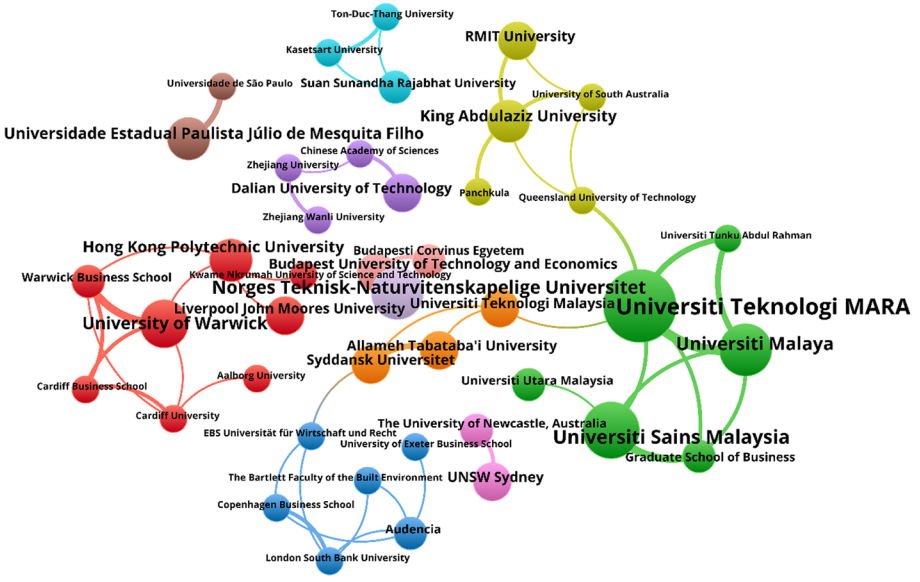

Fig. 4 University research networks

Table 7 Top 10 most productive journals in the green procurement field

Rank	Journal	No. of articles
1	Journal of Cleaner Production	51
2	Sustainability (Switzerland)	25
3	International Journal of Supply Chain Management	15
4	International Journal of Procurement Management	14
5	Journal of Public Procurement	10
6	Journal of Purchasing and Supply Management	10
7	International Journal of Production Research	7
8	International Journal of Production Economics	7
9	Supply Chain Management	6
10	Journal of Manufacturing Technology Management	5

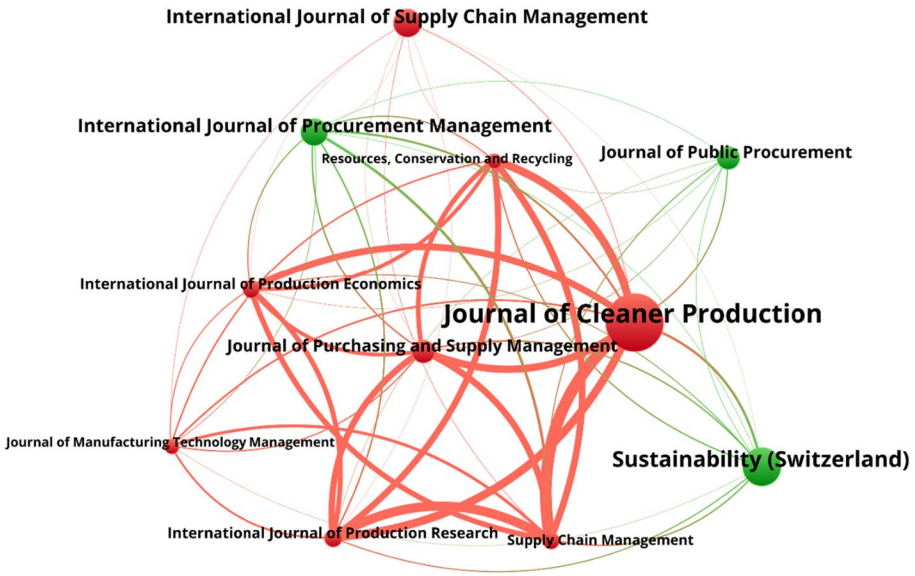

Fig. 5 Source co-citation network

depicted in Fig. 5. The first cluster contains the *Journal of Cleaner Production*, *Journal of Purchasing and Supply Management*, *International Journal of Production Economics*, *International Journal of Production Research* and *Supply Chain Management*. All of these journals are highly reputable outlets in the area of sustainability and supply chain management. The second cluster consists of journals that deal specifically with procurement, such as the *International Journal of Procurement Management*, *Journal of Public Procurement* and *Sustainability* in a broader context. These journals mostly publish articles on procurement and green supply chain management practices.

4 Conclusion, implications, and limitations

This study provides a synthesis of existing research on the green procurement field by conducting a bibliometric analysis to address the three research questions raised in the introduction. To answer RQ1, pertaining to the current status of green procurement research, the most frequent keywords, the most influential authors, the most cited articles, and the most productive countries, universities, and journals were identified to provide a complete overview of the green procurement field. To address RQ2, pertaining to emerging themes and clusters in the field, a co-citation analysis was performed that illustrates the thematic categorization of the existing corpus of literature. Finally, insights derived from co-citation network analysis were used to answer RQ3 by outlining future research avenues and gaps deserving further attention.

Using various bibliometric tools, we increase the understanding of the knowledge structure of existing green procurement literature. In short, our work offers multiple contributions by capturing and discussing the main keywords used in the literature, generating knowledge clusters and identifying semantically related communities in the green procurement field, highlighting research trends, and proposing several directions for future research. The major findings of this green procurement review can be summarized as follows:

- The overall body of literature has seen rapid growth and attracted significant attention over the recent decade, as demonstrated by the marked increase in the number of published articles after the year 2010. However, green procurement is still an infant field and several issues remain unaddressed. For example, there is a need to study the importance of adopting green procurement as a natural advancement of current practices instead of treating it as fundamentally different from conventional procurement (Alberg Mosgaard, 2015). Moreover, there is a need for more qualitative research approaches to advance the green procurement literature and to generate an in-depth understanding of current procedures and their underlying rationale. Researchers also need to consider green procurement not only as an instrument to achieve environmental benefits but also as a tool to foster social sustainability.
- Research on green procurement predominately discusses green public procurement through the exploration of the forces that influence decision makers to engage in this practice (cluster 1), as well as in more general green supply chain management practices (cluster 2). In this regard, a collection of influential papers on green procurement include Zhu and Sarkis (2007), Green et al. (2012), Min and Galle (2001) and Eltayeb et al. (2011).
- Concerning methodology, we notice that most of the research so far has been empirical in nature and relies on different multi-criteria decision making (MCDM) approaches (Naseer et al., 2021; Rostamzadeh et al., 2015; Zhao & Guo, 2014). We also notice a lack of qualitative and case-study-based methods that investigate green procurement.
- Recently, topics related to green supplier selection and adoption of green procurement in construction projects have received significant attention. A thorough investigation of research clusters in two separate periods, 1994–2009 and 2010–2021, indicates the evolution of the field's knowledge structure. The era from 1994 to 2009 represents the buildup of instrumental concepts of green procurement, which mainly focuses on green procurement adoption and implementation. In the later period, there is a stronger focus on green supply chain management practices and the transition process toward green

procurement. We also find several studies that discuss green public procurement and its potential to reduce negative environmental impacts throughout the product lifecycle.

4.1 Research implications

Our bibliometric study identifies the intellectual structure of the green procurement field. Our findings help scholars to comprehend the existing boundaries of this field and to identify potential avenues for future research. Researchers can build on our findings to focus their efforts on the under-researched and novel issues that will most benefit the advancement of green procurement initiatives. Furthermore, they can benefit from our identification of notable academics and institutions in the green procurement field as prospective collaborators and driving forces for further developing research on the subject.

We carry out a comprehensive review of this knowledge field, applying citation and co-citation analyses of studies. The attempts to explain the intellectual structure of green procurement also provide academics with novel insights. A careful analysis of the keywords used over time uncovers the hotspots and core research areas in the green procurement literature. Moreover, we provide a list of the most cited publications to identify the most influential research works in the field. The analysis of these articles and keywords provides a starting point from which to unearth avenues for future studies. Similarly, the results from the analysis of topic clusters revealed by the co-citation network offer researchers essential information about seminal and influential articles that may be considered the roots of the green procurement field. Future scholars will find this information useful, as these papers can serve as a foundation for more sophisticated and nuanced studies on the particular issues revealed by the co-citation clustering. Through the bibliometric analysis, we are also able to determine the most influential scholars and their contributions, which helps to raise awareness of seminal publications that provide inspiration and guidance for future academic studies.

Essentially, we generate clusters that group comparable publications and elaborate on the findings. The publication groupings help to reveal the knowledge structure of green procurement research. The analysis of the thematic clusters enables us to suggest directions that can be taken by other researchers. Our research can also be used as a foundation for advancing methodological developments via additional empirical investigations and mathematical modeling. Interestingly, we identify a lack of studies that examine the intersection between green procurement and emerging technologies. Therefore, future research can fill this knowledge gap by performing empirical investigations that assess the barriers to adopting new technologies in green procurement. Moreover, case study-based research concerning the impact of green procurement on firm and supply chain performance needs to be supported with real data from the industry. Also, engaging procurers and managers can benefit the theoretical and practical advancement of green procurement research.

As there is an urgent need to reduce detrimental environmental impacts and achieve holistic sustainability, the findings of the bibliometric analysis can be of practical relevance to those managers and practitioners who aspire to further advance green procurement practices. From the analysis, we draw five takeaways for organizational policymakers and procurement managers looking to speed up the implementation of green procurement inside their organizations. First, firms can take advantage of green procurement to make supply chains more efficient and reduce transaction costs. Unlike traditional procurement, the implementation of green procurement allows firms to achieve cleaner production, increase economic performance, and promote sustainable products and services to respond

to customers' environmental requirements. However, the advantages of green procurement can only be achieved if the challenges hampering its implementation can be overcome. In this respect, future research must also investigate the economic, operational, and technical feasibility of implementing green procurement. Second, the study findings suggest that managers and practitioners in charge of overseeing procurement activities in a firm need to learn about the many ways in which green procurement can add value and extend sustainability to customers and suppliers. Third, these practitioners can use the findings of prestigious publications, which have been uncovered by the citation and co-citation analyses, to discuss the internal and external drivers that can help to overcome the barriers to the adoption of green procurement in diverse organizational contexts. Our results also highlight the need of conducting practical research into the mechanisms defining the relationship between organizational performance and green procurement. Fourth, the findings reveal that new entrepreneurial modes of sourcing are needed to contribute to green supplier development. Therefore, this research directly addresses purchasing professionals and policymakers involved in green procurement to promote innovation and establish collaboration among green supply chain partners. Fifth, we believe that bibliometrics may help industry-based practitioners define the scope of their own research interests in regard to a more nuanced view of the impact of green procurement adoption on various managerial domains. This includes financial management, human resources, and logistics management.

4.2 Directions for future research

Our analysis also provides numerous ideas for researchers interested in furthering their investigations of green procurement. From a methodological perspective, three distinct avenues for future studies are suggested. As a first step toward a deeper comprehension of the green procurement field, we suggest investigations that complement our study. For example, a bibliographic coupling analysis or a pairing of a bibliometric investigation with topic modeling or content analysis would not only improve the ability to trace the intellectual structure of the green procurement domain, but it would also aid in the development of a set of specific future research paths. Second, we assembled publications using a keyword search. Accordingly, future studies can perform more targeted analyses based on articles from a particular journal or a selection of journals to better comprehend the topic of green procurement. A third potential path for future studies would be to repeat the citation and co-citation analyses after a certain number of years have lapsed. This can also be done in a specific domain. For example, our research from 2000 to 2021 reveals a distinct cluster for green procurement implementation in the construction sector. On this basis, future researchers might perform reviews of the literature dealing exclusively with green procurement in construction.

Considering the relevance of green procurement in the public sector, research into the opportunities and barriers to the implementation of green public procurement has attracted researchers' attention. Recently, policies associated with green procurement have been studied in the construction sector. However, further investigation is needed how green procurement can be applied in other sectors (e.g., healthcare, education, agriculture) to reduce the detrimental impacts of climate change and foster the circular economy.

The growing number of publications on green procurement points to the field's promising future. It is important to thoroughly explore the role of green procurement in mitigating the disastrous effects of climate change (Agyepong & Nhamo, 2017). Investigations

into green procurement have spread across several academic disciplines, including business management, environmental science, social science, operations research, and marketing. Given the multi-faceted character of green procurement, academics from a variety of fields will need to work together to successfully address various cross-cutting issues. By analyzing the most commonly used terms in the pooled data, we can anticipate that research on sustainable development and green procurement will soon receive more attention (AlNuaimi et al., 2021a, 2021b; Geng & Doberstein, 2008; Zhang, 2020). In light of mounting financial pressure and shifting market dynamics, organizations' motivations for adopting green procurement practices need to be clarified. Business and non-business players such as the media, government, and regulatory agencies may need to closely work together if sustainable development is to become one of their main goals (Crespin-Mazet & Dontenwill, 2012). Therefore, future research needs to investigate how to establish cooperative linkages between these players to guarantee the effective contribution to economic growth or sustainable development. To further the implementation of greening practices in the government sector, research on the actions of public procurers and their dedication to sustainability and environmental awareness is also urgently needed.

Research on green procurement has extended to encompass the study of private green procurement due to the increased emphasis on negative environmental repercussions and social challenges (Appolloni et al., 2014). Future studies should look at how crucial industries such as the food, minerals, and transportation sectors may benefit from adopting sustainability values into procurement processes. Such analyses need to investigate whether green procurement is easier to adopt in some sectors than in others and which characteristics are indicative of a successful implementation. Environmental sustainability issues and sustainable development can be better tackled with a deeper understanding of green procurement gained by combining theory with practice. We also advise that academics and procurement managers collaborate to advance the state of green procurement research in a way that is both theoretically and practically relevant. Finally, the analysis of the enablers and barriers to the adoption of Industry 4.0 technologies (e.g., blockchain technology, big data analytics, artificial intelligence, the internet of things, etc.) (Awan et al., 2021, 2022a, 2022b; Ghobakhloo et al., 2021; Rejeb et al., 2022a, 2022b, 2022c, 2022d, 2022e) in green procurement is a fertile and worthwhile research area.

4.3 Research limitations

Our paper has several shortcomings. First, the results are determined by the articles selected for the final review. It is difficult to identify all potentially relevant publications related to green procurement, especially those not indexed in Scopus. Another shortcoming concerns articles with few citations. A bibliometric analysis is inherently biased toward earlier articles because they tend to gain more citations over time. More recent publications need a certain period of time to accumulate citations and attract attention. Therefore, recent publications that may eventually be paradigm shifting could fail to appear in the top influential studies. This shortcoming is common in the investigation of emerging research fields like green procurement. Since we have used Scopus to analyze the literature in this work, future researchers should use other data sources, such as the Web of Science, to broaden the horizon and improve the research structure. Additionally, future works can offer insights into the potential of new technologies to accelerate the transition toward green procurement and achieve economic, social, and environmental sustainability.

Appendix 1

TITLE-ABS-KEY ("Green Procurement" OR "Green Purchas*" OR "Sustainable Procurement" OR "Sustainable Purchas*" OR "Ethical Procurement" OR "Environmental Procurement") AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (EXCLUDE (PUBYEAR, 2022)) AND (LIMIT-TO (LANGUAGE, "English")).

Author contributions AR and AA conceptualized the study; AR, KR, HT helped in methodology; KR contributed to software, data curation, visualization; AA, YK, and HT validated and supervised the study; AR helped in formal analysis, writing—original draft preparation, and investigation; AR, KR were involved in resources; AR, AA, YK, HT performed writing—review and editing; HT administrated the project. All authors have read and agreed to the published version of the manuscript.

Funding Open access funding provided by MODUL University Vienna GmbH. The authors did not receive support from any organization for the submitted work.

Data availability The list of selected publications for the bibliometric analysis is available from the lead author upon request.

Declarations

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent to publish Not applicable.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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