

The landscape of public procurement research: a bibliometric analysis and topic modelling based on Scopus

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Abstract

Purpose – The purpose of this study is to investigate the structure and dynamics of academic articles relating to public procurement (PP) in the period 1984–2022 (up to May). The researchers also intend to analyse how this knowledge domain has grown since 1984.

Design/methodology/approach – A bibliometric analysis was carried out to examine the existing state of PP research. Based on 640 journal articles indexed in the Scopus database and written by 1,247 authors over nearly four decades, a bibliometric analysis was conducted to reveal the intellectual structure of academic works pertaining to PP.

Findings – Findings reveal that PP research from Scopus has significantly increased in the past decade. Major journals publishing PP research are *International Journal of Procurement Management*, *Journal of Cleaner Production*, *Journal of Purchasing and Supply Management* and *Public Money and Management*. Results also indicate that authors' cooperation network is fragmented, showing limited collaboration among PP researchers. In addition, results suggest that the institutional collaboration network in PP research mirrors what is commonly referred to as the North–South divide, signifying insufficient research collaboration between developed and developing countries' institutions. According to the co-occurrence keyword network and topic modelling, PP revolves around five main themes, including innovation, corruption, sustainable and green PP, PP contracts and small and medium enterprises. Based on these results, several directions for future research are suggested.

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Social implications – This paper provides an increased understanding of the entire PP field and the potential research directions.

Originality/value – To the best of the authors' knowledge, this study is the first-ever application of bibliometric techniques and topic modelling to examine the development of PP research since 1984 based on scholarly publications extracted from the Scopus database.

Keywords Public procurement, Innovation, Sustainability, Corruption, Bibliometric

Paper type Literature review

1. Introduction

The purchasing of products and services by public entities, referred to as public procurement (PP), is recognised as a key market force (Obwegeser and Müller, 2018) [1]. As a crucial economic activity of governments, PP contributes significantly to a country's gross domestic product (GDP). A recent report by the Organisation for Economic Cooperation and Development (OECD) indicates that around 12% of the GDP of OECD nations is composed of PP (OECD, 2022). In industrialised countries, PP can account for up to 70% of government expenditure, especially in unstable regimes (Ambe, 2019). Theoretically, PP is described as the purchase of products and services necessary for public institutions to achieve their functional goals (Kristensen *et al.*, 2021). According to Snider and Rendon (2012), PP encompasses a number of methods through which public institutions and entities acquire products and services from external vendors. Likewise, Thai (2001) notes that PP covers several contract management activities, including contracting, buying, leasing and renting, as well as contract administration. Government policy can be supported by PP, which can be used to impact the economy, industry and society as a whole (Harland *et al.*, 2019). For instance, PP can drive innovation (Amann and Essig, 2015) and encourage small-business entrepreneurship (Budak *et al.*, 2017; Hoekman and Taş, 2022). In addition, PP can serve as a mechanism for improving socio-economic circumstances (Unk and Telgen, 2019), thus addressing wider sustainability concerns (Sönnichsen and Clement, 2020). PP can also play an important role in promoting corporate social responsibility (CSR) (Snider *et al.*, 2013). Wontner *et al.* (2020) highlight that PP can influence employment creation and several scholars assert that PP can boost economic growth and improve public service quality in many countries (Uyarra *et al.*, 2020; Vecchiato and Roveda, 2014). Participation of domestic vendors in government contracts has the potential to influence national economies (Uyarra *et al.*, 2020). Consequently, PP can increase the competitiveness of supply markets if effectively leveraged.

Ferreira *et al.* (2014) note that it is crucial for scholars to occasionally reflect on the knowledge created and gathered to inspire contributions, discern research traditions and trends, comprehend which subjects are covered, the methods and theories applied and identify the intellectual structure, knowledge body and perspective topics for future research in a specific field. Scientography refers to the graphic detection of "hidden patterns" in the knowledge landscape of a certain scientific field (García-Lillo *et al.*, 2019). Similarities exist between landscape mapping and cartography in terms of information visualisation, clarity and simplicity (Chen, 2003; Chen and Paul, 2001). However, the aim of scientography is to track knowledge structure and identify research hotspots or frontiers in a certain academic domain by bringing in diverse areas such as information visualisation technology, high-performance computers and advanced digital databases (Zou *et al.*, 2018).

The recent 15 years have seen a tremendous expansion in the PP literature, with a number of reviews examining different aspects of PP. For instance, Raymond (2008) examines the basic principles of PP and how they can be benchmarked in a literature review.

According to [Raymond \(2008\)](#), reform solutions for PP processes must address issues of openness, value for money, accountability, ethics and a professional workforce. [Cheng et al. \(2018\)](#) summarise the literature pertaining to green PP (GPP) based on English-language papers published between 2000 and 2016. The study indicates that previous research focuses mostly on the specific effects of GPP adoption, while the efficiency and innovation implications of GPP compared to other environmental policy instruments are neglected. In a similar spirit, [Sönnichsen and Clement \(2020\)](#) conduct a comprehensive analysis of early articles on sustainable and green procurement. Awareness and comprehension of circular PP characteristics, based on the development of a circular strategy and policy, are essential for the realisation of circular PP, according to this research. Moreover, [Burghardt and Pashkevich \(2021\)](#) examine the fundamental aspects of GPP and uncertainties in road marking materials, including paints, plastic masses and tapes. Lastly, [Hamilton \(2022\)](#) evaluates the emerging landscape of PP policy and supply chain regulation in high-income economies by examining the grey and academic literature. According to the findings of the review, leading nations are adopting a mandated approach to sustainable PP (SPP) and due diligence regulations are shifting supply chains from reputational harm to legal liability. Additionally, themes associated with technological innovation and green production occupy a prominent place in the SPP literature, while themes concerning social sustainability, poverty, inequality and human rights remain ignored.

Although these studies offer academics several insights, a bibliometric examination of the PP domain as a whole is currently lacking. This is unexpected, considering that several scholars have recently applied bibliometric analyses to explore a multitude of scientific fields ([Aazami et al., 2020](#); [Abdollahi et al., 2021](#); [Chandra and Shukla, 2021](#)). Recently, [Wallace \(2018\)](#) recommends the use of “relational turn” in the analysis of Web-generated content. Accordingly, we adopt a bibliometric network analysis and topic modelling to highlight the connectivity of PP-related works and investigate the overall structure of the PP knowledge domain. By undertaking this study, we contend that we have made at least three substantial contributions to the existing body of knowledge. Firstly, this is, to the best of our knowledge, the first attempt to examine the PP literature since its initial development. Therefore, analysing the dynamics and structure of academic papers dealing with PP adds to the large body of research investigating procurement management in public institutions. Secondly, by undertaking a bibliometric analysis of scholarly PP-related publications, we expand bibliometric research. Several scholars have advocated that bibliometric analyses should shift their emphasis from bounded offline sites to connections ([Levitt, 2013](#); [Mostafa, 2020](#)). Thirdly, by concentrating only on academic publications pertaining to PP, we enrich the literature in this field. Specifically, we attempt to answer the following research questions:

- RQ1.* How has PP research evolved since its exposure in the Scopus database?
- RQ2.* What are the current research foci of scholars and knowledge structure (i.e. the relationships between the concepts) in the selected publications?
- RQ3.* Who are the most prominent authors and publications in the PP domain?
- RQ4.* Which scholars and institutions demonstrate the highest levels of collaboration in the PP domain?

This review is organised as follows. Section 2 describes the four-step method used to apply the bibliometric analysis. Next, in Section 3, the research results are discussed. Based on the findings of the bibliometric analysis, Section 4 suggests several directions for future research. Finally, we discuss research findings, implications and limitations in Section 5.

2. Research method

Our bibliometric study is based on a four-step approach suggested by [Fosso Wamba and Mishra \(2017\)](#):

- (1) specify the search database and the keywords;
- (2) conduct a preliminary analysis of the data;
- (3) analyse bibliometric networks; and
- (4) perform thematic analysis, conceptual structure analysis and historiographic analysis.

The study used several tools, including R software, bibliometrix, rentrez, ggplot2 and wordcloud. Moreover, VOSviewer was used to generate and visualise the bibliometric networks ([van Eck and Waltman, 2009](#)). This computer program was chosen because of its ability to combine text mining techniques and visualisation, thereby enabling the efficient handling of network visualisation tasks. This section discusses in detail the method used.

2.1 Selection of database and search keywords

We extracted all publications related to PP from Scopus. This academic database is one of the largest repositories for abstracts and citations of peer-reviewed documents, including journal articles and conference proceedings ([Omotehinwa, 2022](#)). Scopus also has numerous operating functions that simplify the application of bibliometric analyses and it is extensively used by researchers to obtain high-quality analyses ([Aazami et al., 2020](#); [Yao et al., 2018](#)). As a property of Elsevier, Scopus is relatively more comprehensive than PubMed or Web of Science (WoS). For example, [Garrido-Cardenas et al. \(2020\)](#) argue that Scopus covers 84% of the WoS titles, whereas only 54% of the publications in Scopus are indexed in WoS. Scopus is also more precise than Google Scholar because of its superior control over the referred publications and the controlled indexing ([Dinić and Jevremov, 2021](#)). As a result, the Scopus database was the only reasonable option for conducting the study because of its accessibility and extensive coverage of peer-reviewed academic literature ([Mongeon and Paul-Hus, 2016](#)). The gathered data included the authors' names, publication titles, journals, publication types, abstracts, authors' affiliations and articles' numbers. For further analysis, these data were extracted and exported in CSV format. Consistent with [Cheng et al. \(2018\)](#), the following search string was used in the article's title, abstract and keywords fields to extract data from Scopus: "public procurement" OR "public purchas*" OR "government procurement" OR "government purchas*". The use of this search string enabled us to obtain a manageable number of articles for the manual screening and to reduce false positive results because of the lack of precise keywords unrelated to the study subject. Only journal articles and reviews written in English were selected since they represent a source of peer-reviewed and certified knowledge ([Ramos-Rodríguez and Ruiz-Navarro, 2004](#)). The search was done on 29 May, 2022, and 977 articles were located. Next, the titles and abstracts of the publications were evaluated for relevance, resulting in the elimination of 337 publications owing to a lack of relevance to the topic of the research. Thus, 640 articles were selected for the final analysis [1].

2.2 Preliminary analysis of publications

A BibTeX format of all publications' metadata was retrieved, including authors' names and articles' titles, abstracts and keywords. The main information related to the selected sample is presented in [Table 1](#). The table shows that the collaboration index was 2.36. [Ajiferuke et al. \(2005\)](#) introduced the collaboration index, which is considered a unique metric for

Description	Results
<i>Main information about data</i>	
Timespan	1984–2022 (up to May)
Sources (Journals)	247
Documents	640
Average years from publication	6.56
<i>Document types</i>	
Article	621
Review	19
Document contents	
Keywords plus (ID)	1,119
Author's keywords (DE)	1,729
Authors	
Authors	1,247
Author appearances	1,556
Authors of single-authored documents	148
Authors of multi-authored documents	1,133
<i>Authors collaboration</i>	
Single-authored documents	168
Documents per author	0.507
Authors per document	1.97
Co-authors per documents	2.43
Collaboration index	2.36

Table 1.
Main information
about the selected
sample

fractional productivity, drawing on the research of [De Solla Price and Beaver \(1966\)](#). In this index, a number close to zero indicates that single-authored publications predominate. Researchers conducting meta-analytic works argue about the inclusion of publications in the analysis. For instance, [Della Corte et al. \(2018\)](#) selected journal publications solely, whereas the work of [Aryadoust and Ang \(2021\)](#) was based on books and journal publications. This study only included peer-reviewed journal articles.

2.3 Network analysis

Social network analysis (SNA) represents a multi-disciplinary analytic approach that incorporates computer science, statistics and mathematics and it has evolved swiftly into a formal analysis technique. From a network perspective, the use of the SNA approach in the synthesis of the current literature can uncover useful hidden patterns that can help theory development and identify future research areas ([Khan and Wood, 2016](#)). While numerous statistical metrics have been created to analyse a network ([Knoke and Yang, 2019](#)), this study primarily considers three metrics: network size, diameter and density. In the academic literature, SNA approaches have been applied extensively. Previous studies have, for instance, explored co-citation networks ([Rejeb et al., 2022](#); [Sanguri et al., 2020](#)). According to [Li et al. \(2022\)](#), a co-citation network represents a knowledge network comprised of two publications simultaneously referenced in a third publication and it indicates the scientific foundation and development trend of a certain research field. Furthermore, co-citation networks are useful for evaluating the semantic similarity between publications or authors ([Yang et al., 2015](#)). Studying co-citation trends across time enables researchers to uncover paradigm changes in academic fields ([Gmür, 2006](#); [Kraus et al., 2020](#)). Furthermore, the structure of a knowledge field can be revealed using source co-citation networks ([Ji et al., 2020](#)). [Wakefield \(2008\)](#) notes

that source co-citation can visually demonstrate the knowledge patterns that possibly imply similarities across academic journals, such as methodology or research scope. Finally, collaboration networks are widely used in several bibliometric studies (Peng *et al.*, 2017; Rejeb *et al.*, 2021). As a valuable bibliometric tool, collaboration networks constitute a graphical representation (map) in which nodes indicate authors, countries or institutions and linkages between nodes reflect co-authorships between researchers, institutions or countries, i.e. international cooperation in academic research (Ramos-Rincón *et al.*, 2019). Specifically, researchers' collaborative efforts were discovered to achieve mutual benefits, promote research innovation and knowledge dissemination and enhance research quality (Zou *et al.*, 2018). Similarly, Glänzel and Schubert (2005) observe that compared to single-authored publications, those written by many authors have a greater chance of being published in high-impact journals and getting more citations. Ding (2011) further shows that co-operation across universities can foster research partnerships, thereby benefitting policymaking efforts. Lastly, keyword co-occurrence networks can help to capture signal-words or core research themes discussed in a certain knowledge field (Rejeb *et al.*, 2020). As a valuable data mining technique, a keyword co-occurrence network analysis enables researchers to understand the major streams of inquiry that have shaped the development of the PP field (Zhang *et al.*, 2022). In the network, each node represents a keyword and its colour reflects the cluster to which it has belonged. The size of the node is proportional to the occurrence of the keyword and the thickness of the edges indicates the strength of connection between two keywords (Rejeb *et al.*, 2020).

2.4 Analysis of the thematic and conceptual structure

The centrality and density metrics of Callon *et al.* (2005) serve as the foundation for strategic or thematic maps initially introduced by Law *et al.* (2005). These maps help researchers to explore the development of themes obtained from the co-occurrence of keywords (Agbo *et al.*, 2021; Sharma *et al.*, 2021). The methods used to create these maps draw inspiration from both co-word networks and financial portfolio analysis (Zong *et al.*, 2013). The strength of the thematic map lies in its ability to differentiate the centrality and density of research within several categories (Mobin *et al.*, 2021). The density of a theme indicates its progress, while centrality describes the extent of the relation among different themes (Esfahani *et al.*, 2019). The construction of a thematic map, which determines themes by grouping recurrent keywords, offers additional objective insights beyond those provided by the conceptual structure map (Bajaj *et al.*, 2022). With the use of a thematic map, it is possible to intuitively and easily identify the core themes and provide the groundwork for further investigation of the different categories to which themes are assigned (Cobo *et al.*, 2011). In the academic literature, thematic maps have been widely applied (Martínez-Vázquez *et al.*, 2021; Mumu *et al.*, 2021).

Another way to visualise knowledge is through conceptual structure maps. Using these maps, a scientific field may be broken down into different research clusters (Bajaj *et al.*, 2022; Raza *et al.*, 2020). Keywords are shown as points on the map, and results are shown according to the relative position of the points. Closer points suggest more publications discussing the concepts together, whereas farther-apart points imply fewer publications discussing the concepts together (Cuccurullo *et al.*, 2016). As a result, keyword citation bursts or emerging research trends can be identified in this manner (Cobo *et al.*, 2011). In other words, it is possible to better comprehend which research hotspots commonly arise in the literature (Guo *et al.*, 2021).

3. Results

3.1 Scholarly production, main journals and prominent authors

We began by tracking the development of PP research. Figure 1 depicts the number of articles discussing PP. We can observe from the figure that few papers were published each year through 2008, suggesting that scholarly production looks to be somewhat limited. This phase can be termed the initial stage of PP research. Since 2009, the number of papers published on PP has grown significantly, indicating the strong interest of researchers in the PP field (Ambe, 2019; Cheng *et al.*, 2018). The past decade is characterised by a boom in academic output; thus, it can be referred to as the growth phase of the PP domain. As per Cutcher *et al.* (2020), PP represents an essential mechanism of modern public governance owing to the participation of non-government actors in achieving policy goals. For this reason, it is anticipated that the number of papers on PP will expand in the years to come.

Figure 2 depicts a wordcloud of the impactful Scopus-indexed journals publishing academic papers on PP. It is used to present the most influential journals in the field, where the size of the label corresponds to the number of citations received by the journal. From the chart, it is obvious that the most influential outlets publishing in the PP field are journals like *Journal of Cleaner Production*, *Research Policy*, *Journal of Purchasing and Supply Management*, *International Journal of Operations and Production Management* and *Supply Chain Management*.

The Bradford law is useful for assessing the output of academic journals (Kumar and Dora, 2011). The law emerges from the need to identify the relevant journals that publish articles on the topic of interest throughout the time frame of the research (Burrell, 1989). According to the law:

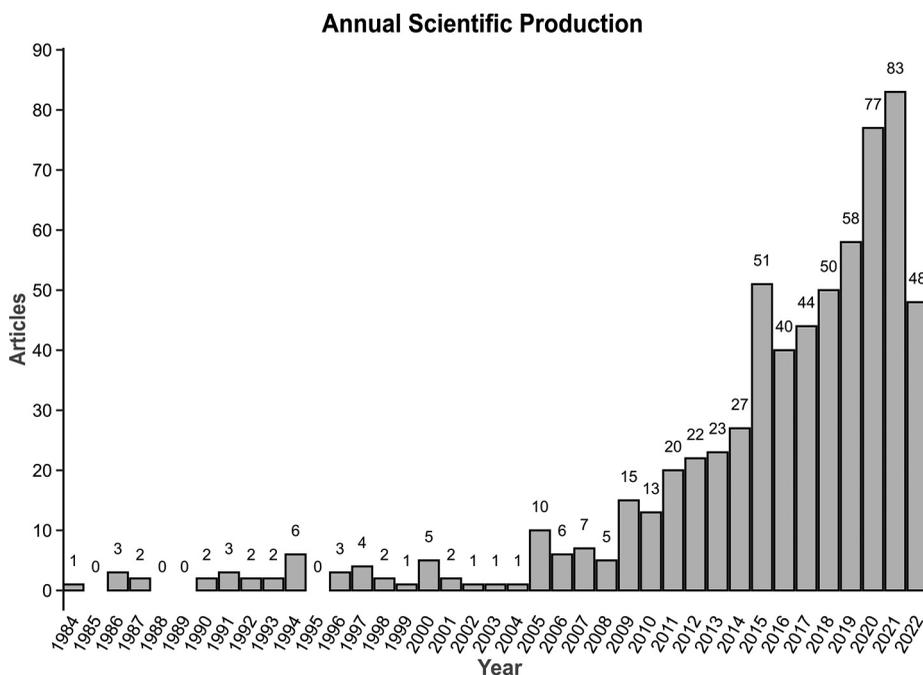


Figure 1.
Annual scholarly
production in the PP
field (1984–2022 up to
May)



Figure 2.
Most influential
journals publishing
PP research

[...] if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus (Bradford, 1934, p. 85).

Figure 3 depicts the Bradford law in the academic publications discussing PP. When applying the Bradford law, via R-Biblioshiny, the inverse relationship of Bradford (1934) is obvious, as the first zone of the figure represents the core zone (or Bradford zone 1) and comprises a small number of academic journals such as *International Journal of Procurement Management*, *Journal of Cleaner Production*, *Journal of Purchasing and Supply Management* and *Public Money and Management*. This suggests that just eight outlets account for the majority of PP-related research articles (Table 2).

Figure 4 shows the dominance of authors throughout time as reflected in the Scopus database. Yakovlev A. dominated from 2015 to 2022, Tkachenko A. from 2015 to 2021 and Patrucco A.S. from 2017 to 2021 (Table 3). It seems from the graph that Davis P.'s reign of dominance remained for a brief period (2015–2017). The current research measures the concentration of PP contributors using Lotka's law (Patra and Mishra, 2006). This law asserts that the number of authors publishing n articles should be proportionate to $1/n^2$ if authors are ordered according to the number of their publications (Yeung, 2018). In brief, according to Lotka's law, there exists an inverse connection between the number of authors and the number of publications produced by each author (Kinnucan and Wolfram, 1990). We used the bibliometrix R-package to apply Lotka's law to the PP literature. Figure 5 shows the Lotka's distribution. At the standard 0.05 significant level, the Kolmogorov–Smirnov two-sample test reveals no statistically significant differences between the empirical and theoretical distributions. Moreover, the long tail for single-publication authors illustrated in

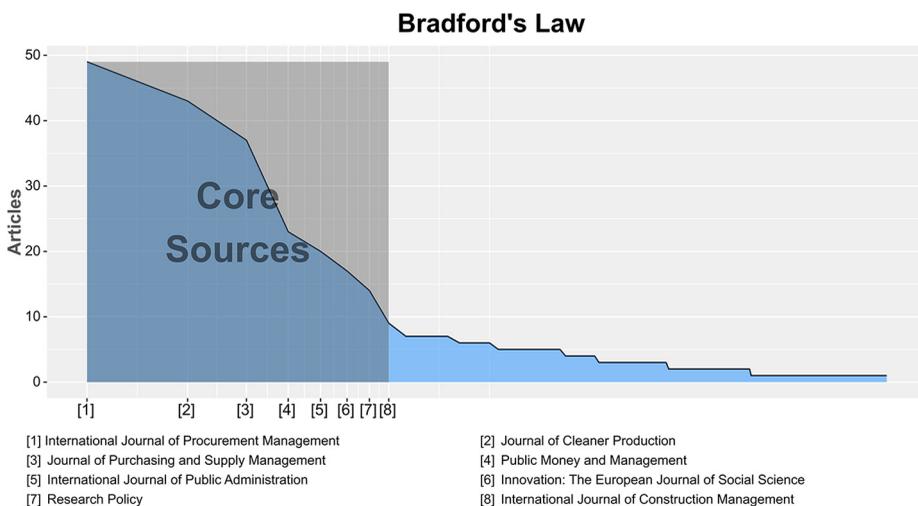


Figure 3.
Bradford law in PP research

Source: log(Rank)

Journal	No. of articles
<i>International Journal of Procurement Management</i>	49
<i>Journal of Cleaner Production</i>	43
<i>Journal of Purchasing and Supply Management</i>	37
<i>Public Money and Management</i>	23
<i>International Journal of Public Administration</i>	20
<i>Innovation: The European Journal of Social Science Research</i>	17
<i>Research Policy</i>	14
<i>International Journal of Construction Management</i>	9
Others (151 journals)	339

Table 2.
Most productive journals in the PP field

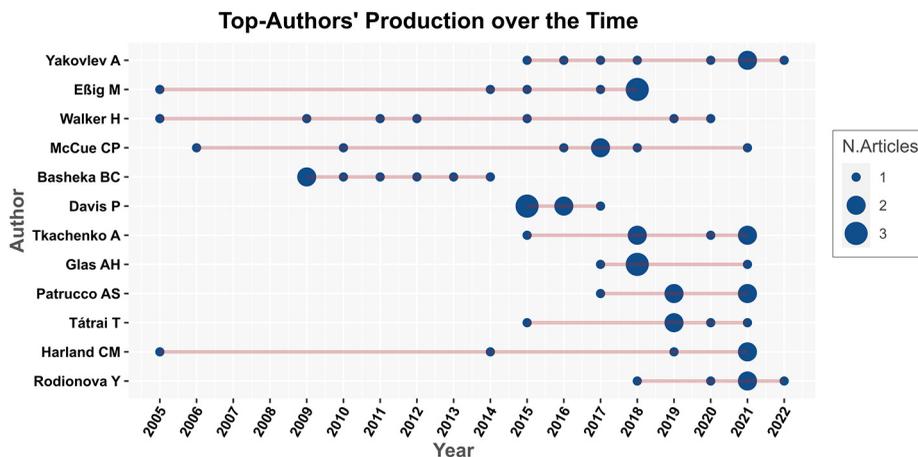


Figure 4.
Most prominent authors in PP research

Table 3.
Most prominent
authors in the PP
field

Author	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Yakovlev A.	1									1	1	1	1	1	1	1	2	1
Eßig M.	1									1	1	1	1	3				
Walker H.				1		1	1	1			1	1	2	1	1		1	
McCue C.P.		1				1	1	1										
Basheka B.C.				2		1	1	1	1		3	2	1	2				
Davis P.											1							
Tkachenko A.											1		1	2		1	2	
Glas A.H.													1	3			1	
Patrucco A.S.													1		2		2	
Tátrai T.															2	1	1	
Harland C.M.	1									1					1		2	
Rodionova Y.														1		1	2	1

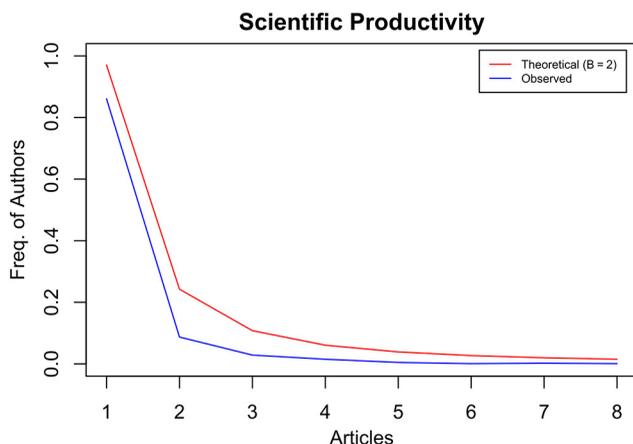


Figure 5. Lotka's law in PP research

Figure 5 implies that some scholars have investigated PP as a subordinate study subject. Based on the findings, it seems that Lotka's law holds true in PP-related articles. Similar findings are also observed in other fields of study (Vieira and Brito, 2015).

3.2 Network analysis

3.2.1 Collaboration networks. Figure 6 shows the authors' collaboration network in the PP field, with a size of 1,247, density of 0.002 and diameter of 7. According to network data, collaboration among authors is rather weak. The figure depicts a few closely connected

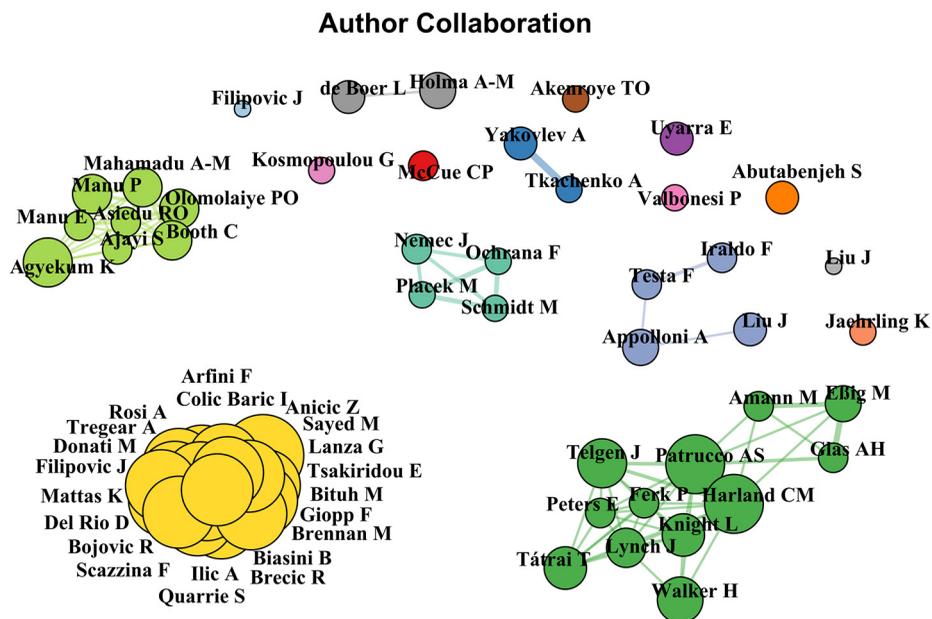


Figure 6. Authors' collaboration network in PP research

research communities distinguished by their respective colours. The remainder of the network is fractured, showing that the most prominent scholars prefer to work in silos. The involvement of islands cut off from the rest of the scientific community is also confirmed in previously published results (Khan and Wood, 2016). Furthermore, Figure 7 depicts the institutional collaboration network in the PP field, with a size, density and diameter of 712, 0.003 and 14, respectively. The network demonstrates little collaboration between institutions, for instance, the University of Manchester, Alliance Manchester Business School and Aalborg University collaborate extensively. This sort of collaboration has been dubbed “locally-centralised globally-discrete” by Zou *et al.* (2018). It may also reflect a North–South divide since, despite the fact that research collaboration among the UK universities is robust, research cooperation between academic institutions from developed and developing countries is limited. Interestingly, language and geographic proximity seem to be the driving forces for research collaboration in the PP field.

3.2.2 *Analysis of keywords and keywords co-occurrence.* Keywords, despite their high abstraction, have been widely employed in academic research to reveal core content and thematic trends in academic publications (Abdollahi *et al.*, 2021). Figure 8 depicts a wordcloud consisting of keywords from PP-related publications’ abstracts. The figure shows that “procurement”, “public”, “innovation”, “contract”, “government” and “policy” are the most often used search terms. Figure 9 shows the keyword growth dynamics based on keyword plus. Keywords that experience abrupt bursts indicate trends and priorities in PP research (Neff and Corley, 2009). Examples of keywords include GPP (green public

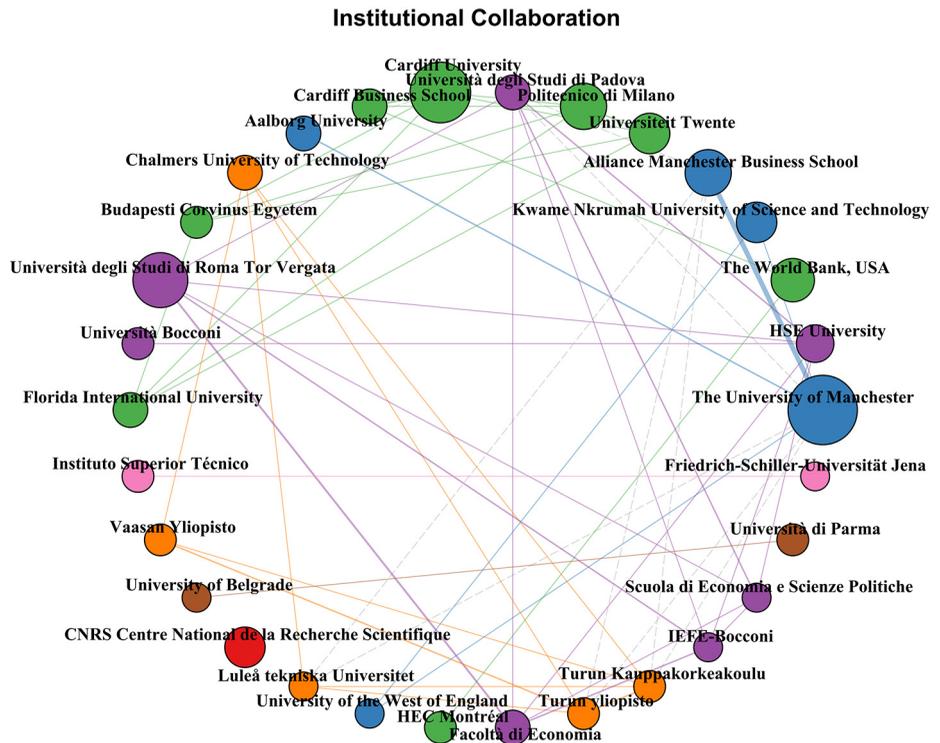


Figure 7. Institutional collaboration network in PP research

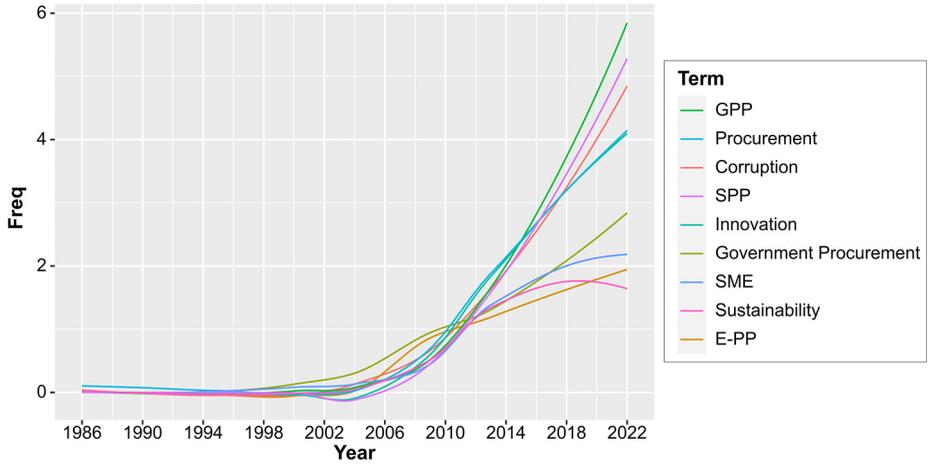


Figure 9. Growth dynamics of keywords in PP research

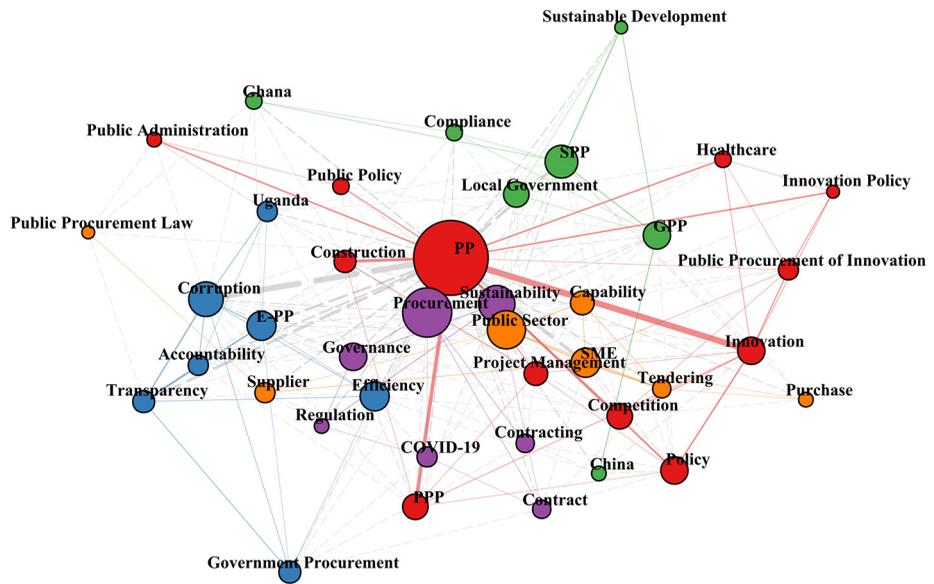


Figure 10. Keyword co-occurrence network in PP research

to better value-added e-Government services, enables efficient resource management and organisational operations and promotes economies of scale. As a result, PP plays a vital role in facilitating the generation and synchronisation of knowledge across all phases of the market growth process.

The keyword “PPP” (public-private partnerships) appears more frequently in the cluster, indicating the importance of this procurement model in PP research. Conceptually, public-private partnerships (PPPs) refer to a wide variety of private and public sector collaborations in the academic literature (Almarri and Abuhijleh, 2017; Carbonara and Pellegrino, 2020; Dolla and Laishram, 2019). More specifically, PPPs are specific contractual

agreements between public and private entities created to finance, develop, manage and maintain infrastructure (Chou and Pramudawardhani, 2015). However, it has been suggested that various forms of public arrangements, from conventional contracting to innovative procurement (Obwegeser and Müller, 2018; Sirotkina and Pavlovskaya, 2018), can benefit from partnership traits, including mutual aims, trust and a sense of reciprocity. As a result, the PPP concept is used here to comprehend common collaborative connections between private and public enterprises (Essig and Batran, 2005; Torvinen and Ulkuniemi, 2016). The quality and consistency of public services can be enhanced through PPPs if they are managed effectively by increasing resource and risk sharing, lowering transaction costs, encouraging closer inter-firm collaboration and clarifying contract specifications (Erridge and Greer, 2002; Kwak *et al.*, 2009). To begin PPP planning, it is necessary to identify and document any potential risks that can arise throughout the project's development. The risks of a PPP project are different since they depend on the specific services provided and the project itself. Despite this, many different PPPs have similar risks, which allows for classifying PPPs into risk categories. For example, risks facing PP projects can be divided into commercial risks and political and legal risks. Two subsets of commercial risks include demand risks and supply risks. The potential risks associated with demand revolve around the possibility that the actual user volumes may fall short of projections. In contrast, the risks related to construction and operations are two types of supply risks. In addition, political and legal risks include government policies, resolution of disputes, taxes and regulations. Certain kinds of PPP projects also include standard risk lists and recommended risk allocations that can help with risk identification. Nonetheless, the complexity and uniqueness of certain PPP projects need substantial study by professionals to identify the risks involved. In the context of PPP projects in Singapore, Hwang *et al.* (2013) highlight that the development of a well-organised public agency, the setting of adequate risk allocation and sharing, the formation of a strong private consortium and the introduction of innovative, creative and cost-effective solutions can be possible measures to circumvent critical risk factors to PPP. Similarly, Ameyaw and Chan (2016) find that commitment of partners, consortium strength, asset quality and social support, political environment and national PPP unit represent the main critical success factors for the implementation of water PPP projects in developing countries.

The second blue cluster revolves around corruption and the solutions to overcome this issue in PP. As such, corruption is defined as the use of public authority for private benefits (Sharma *et al.*, 2019). Theft, embezzlement, bribery, exploiting conflicts, improper political contributions and abuse of discretion are all examples of corruption (Neupane *et al.*, 2014). Corruption in the PP context is linked to insufficient professionalisation of national bureaucracies, hidden and improper procurement planning, lack of a monitoring and controlling system, transparency issues and lack of accountability (Psota *et al.*, 2020). Therefore, the development of reliable PP performance measurements is essential for curbing corruption practices (Osei-Tutu *et al.*, 2010). Public e-procurement can also be adopted to minimise the risk of corruption in PP activities because it enables to monitor and standardise procurement, improve accountability and transparency, promote effective governance and ameliorate the delivery of public sector services (Neupane *et al.*, 2014).

The third cluster (green-coloured) concentrates on SPP and GPP. SPP represents one of the essential policy instruments that governments may employ to solve sustainability concerns (Amann *et al.*, 2014; Etse *et al.*, 2021). Romodina and Silin (2016) argue that SPP comprises a combination of practices, policies and laws intended to integrate economic, social and environmental risks into PP activities and decisions to maximise profitability across the whole product life cycle. Unlike SPP, GPP focuses mainly on the environmental

dimension of sustainability and aims to facilitate the achievement of environmental goals via green purchasing (Cheng *et al.*, 2018; Malatinec, 2019). GPP is also of significant value in countries and regions where it is extensively implemented, as it promotes resource sustainability for future generations, encourages the market to be more innovative in the development of environmentally-friendly products and services and lowers the overall costs of purchasing and disposing of products and services (Ngunjiri, 2019).

The fourth cluster (purple-coloured) deals with PP contracts and includes keywords such as procurement, sustainability, contracting, contract, governance, regulation and COVID-19. As a PP contract is being carried out, private operators may propose novel approaches to enhance the quality of services beyond the baseline expectations. For example, recent developments in waste treatment include renegotiated contracts with the French firm SARP to include new equipment for facilitating the extraction and valorisation of metals like Nickel and Zinc from the waste collection centres. This innovation, prompted by environmental issues, is expected to improve the worldwide quality of waste treatment. To address PP limitations, the public sector can rely on partnerships in the form of contracts to accomplish common objectives in critical crises such as COVID-19 since they increase the public sector's flexibility and capability to deliver services to communities (Vecchi *et al.*, 2020).

Finally, the fifth cluster (orange-coloured) focuses on the role of small and medium enterprises (SMEs) in PP. Related keywords in this cluster include public sector, SME, capability and tendering. The involvement of SMEs in PP is a challenging task, and according to Flynn and Davis (2017), SMEs should allocate resources to improve their tendering capabilities and develop buyer involvement plans. The firm size, measured by the number of employees, is also proven to considerably influence the tendering resources, behaviour and success of SMEs (Flynn *et al.*, 2015). As a result, micro-businesses have less resources, tender less frequently and have a far lower rate of success compared to their larger counterparts.

3.3 Topic modelling

To obtain a deeper understanding of the main topics discussed in the journal articles researching PP, topic modelling approaches were applied to the articles' abstracts, as it is commonly believed that abstracts reflect the core substance of publications (Chen *et al.*, 2020). Conceptually, topic modelling represents a machine learning approach that searches for patterns in the usage of words and injects semantic meaning into vocabulary, where a topic is a cluster of often occurring words (Greene *et al.*, 2014). Topic modelling simplifies the analysis of vast volumes of unlabelled text, links words with related meanings and differentiates the usage of words with numerous meanings (Zou *et al.*, 2015). Typically, topic modelling is employed to uncover latent topics or themes in a text corpus (i.e. a large group of text documents). This approach considers each topic to be a composite of many various themes in a given text. The current study applied the Latent Dirichlet Allocation (LDA) technique to identify the latent topics hidden in the abstracts of the selected PP-related publications (Hino and Fahey, 2019). Generally, this technique has been widely used in studies examining public discourse and sentiment during the COVID-19 pandemic (Xue *et al.*, 2020), Industry 4.0 (Janmajaya *et al.*, 2021) and world trade (Kozłowski *et al.*, 2021). We began by preprocessing text to enhance data quality (Chen *et al.*, 2021). In particular, we used tokenization (i.e. the process of dividing a piece of text into words) to break down abstracts into word units, and we applied normalisation to change all uppercase characters to lowercase. Additionally, stemming was used to diminish inflected versions of words. Punctuations, stop words and numbers were also eliminated since they are poorly

descriptive of the publication's substance (Salton, 1991). The LDA process resulted in six major topics covered in the PP literature, as shown in Figure 11. From the figure, we observe that the first topic focuses mostly on GPP, while the second topic is related to innovation and SMEs in PP. The third cluster deals with sustainability efforts in local government procurement practices. The fourth topic discusses PP contracts and describes how the public sector can implement social targets and policies by contracting with other parties through PP activities. The fifth topic concerns the menace of corruption in PP and the need for standardisation of PP processes and enhanced compliance to combat this issue. Finally, the sixth topic studies several aspects of PP contracts, including costs, competition and prices.

3.4 Conceptual structure and thematic maps

To explore the conceptual structure of the PP field, we conducted a multiple correspondence analysis (MCA). In the R-bibliometrix package, MCA was used to generate the conceptual structure map by evaluating the proximity of keywords in articles (Demiroz and Haase, 2019). Distributionally comparable keywords are shown closer together on the map (Mobin et al., 2021). Furthermore, we drew on R's conceptualStructure function to retrieve author keywords. We also applied k-means clustering to form clusters with common concepts, considering the homogeneity of terms in the map (Aria and Cuccurullo, 2017; Nita, 2019). This k-means algorithm is widely applied for clustering, and its use with MCA generates a

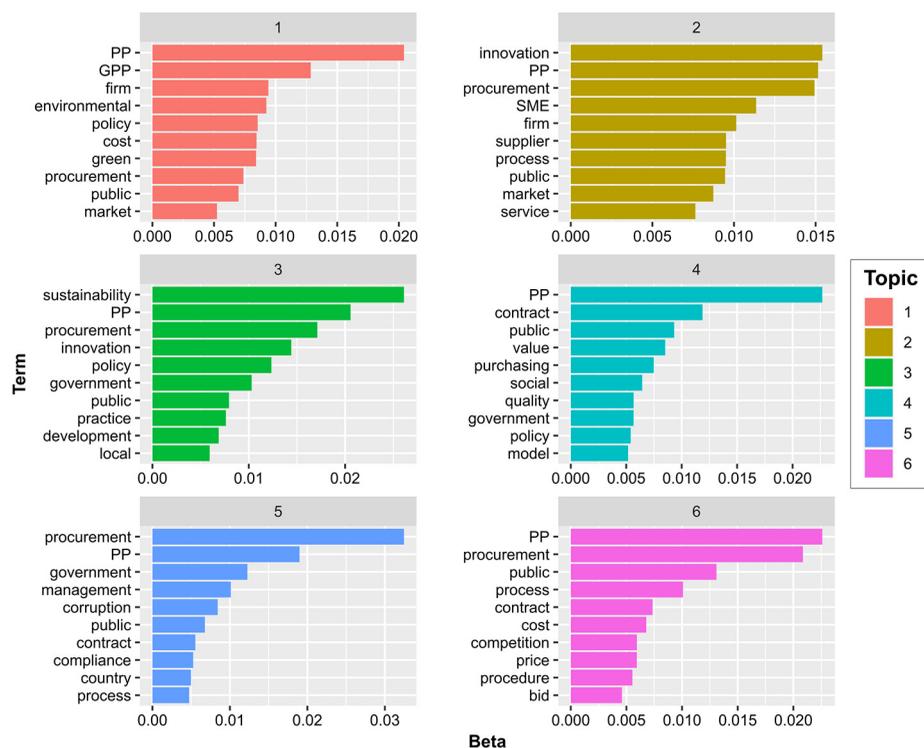


Figure 11.
PP topic modelling
using the LDA
technique

two-dimensional plot that depicts the most relevant keywords and their associations and highlights emerging research trends in the knowledge field (Zhang *et al.*, 2017).

Figure 12 depicts the conceptual structure map of the academic publications related to PP. The diagram illustrates two different clusters for the PP research’s intellectual structure. The red cluster contains keywords that concentrate on three main aspects of PP, including sustainability, innovation and SMEs. Sustainability, SPP, GPP, sustainable development, innovation, PP of innovation and SME are a few examples. Representative studies include Cheng *et al.* (2018), who note that GPP has the potential to play a significant role in modifying unsustainable consumption and production patterns because it is based on the incorporation of environmental concerns into the procurement of public products and services. In addition, Sønnichsen and Clement (2020) evaluate the literature pertaining to GPP and SPP and point out that these forms of procurement have characteristics that make PP more complicated than tendering and buying situations based on the lowest upfront price. Related to innovation, representative studies include Edler and Georghiou (2007), who describe PP as a crucial part of demand-oriented innovation strategy; Aschhoff and Sofka (2009), who incorporate PP within the larger context of public policies to promote innovation; and Georghiou *et al.* (2014) who look into the essentials of innovation procurement policy and provide a comprehensive taxonomy of procurement tools and rules that have emerged in OECD countries. In the SME context, representative studies include Karjalainen and Kemppainen (2008), who explore the type of resources and attributes that influence SME participation in PP; Loader and Norton (2015), who examine the issues facing SMEs in serving the public sector; and Kidalov and Snider (2011), who offer a comparative perspective of PP policies for SMEs in Europe and the USA.

The second cluster in blue includes keywords like corruption, electronic PP (E-PP), transparency and efficiency. This cluster revolves around corruption in PP and the solutions to battle this ubiquitous issue. Representative studies include Chiappinelli (2020), who

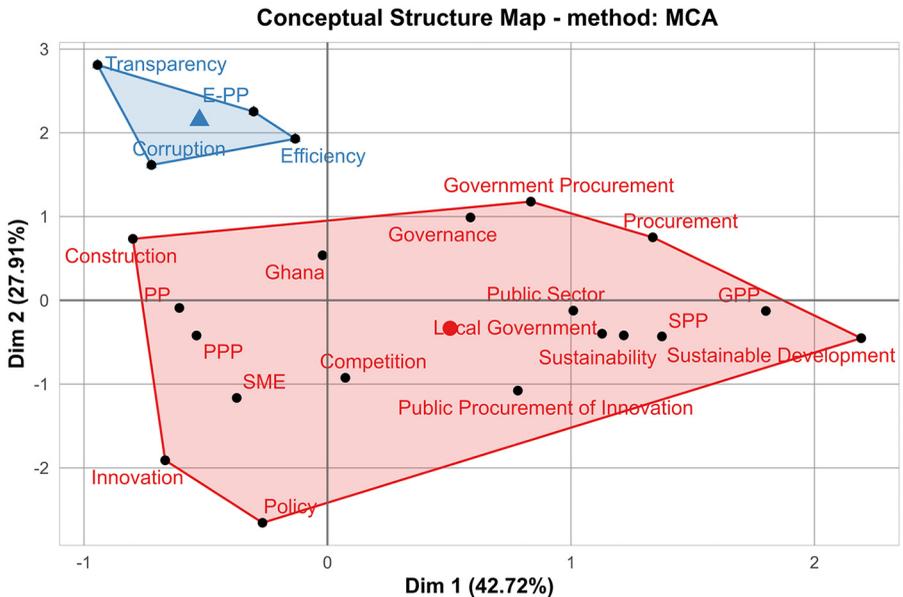


Figure 12. Conceptual structure map of PP research

presents a novel theoretical framework for understanding the predominance of PP corruption; Grossi and Pianezzi (2018), who analyse the importance of public accountability in the fight against PP corruption; and Neu *et al.* (2015), who argue that effective anti-corruption strategies rely on knowledge and evaluation of politics and practises and that transparent structures can impede corrupt PP actions and influence organisational ethics.

Figure 13 depicts the thematic or strategic map of PP research. The sizes of the bubbles represent the number of times the keywords appear in the selected publications. According to Cobo *et al.* (2011), the quadrant of the motor themes contains both internally and externally well-developed themes that are characterised by a high density and a high centrality. Further, the quadrant of the niche themes includes all themes with well-developed internal connections and marginally important external connections. Such themes are also described as isolated and highly developed in the literature. The quadrant of the emerging or declining themes comprises all themes that have weak internal and external linkages and are featured by a low density and centrality. The quadrant of the basic themes contains themes characterised by low density and high centrality. These themes have weak internal linkages but significant external linkages. To this end, themes with high density and centrality are situated in the first top-right quadrant. Therefore, themes within this quadrant are well-established and can impact the research field. Consequently, themes such as “Innovation”, “PPP”, “Public Procurement of Innovation” and “Construction” have remained foundational and pervasive over the four decades of PP research. In contrast, themes like “Sustainability”, “Governance”, “Contracting” and “Compliance”, “Corruption”, “E-PP”, “Transparency” and “Efficiency” are featured by low density but high centrality, indicating that although they can impact other topics, they are not completely established and may inform future research gaps. Keywords in the upper-left quadrant, including “SME”, “Tendering” and “Capability” constitute a niche theme that is well-developed with regard to internal linkages but has weak external linkages and is of minimal relevance. Keywords situated in the lower-left quadrant such as “GPP”, “SPP” and “Sustainable Development” are examples of weakly developed and emerging themes.

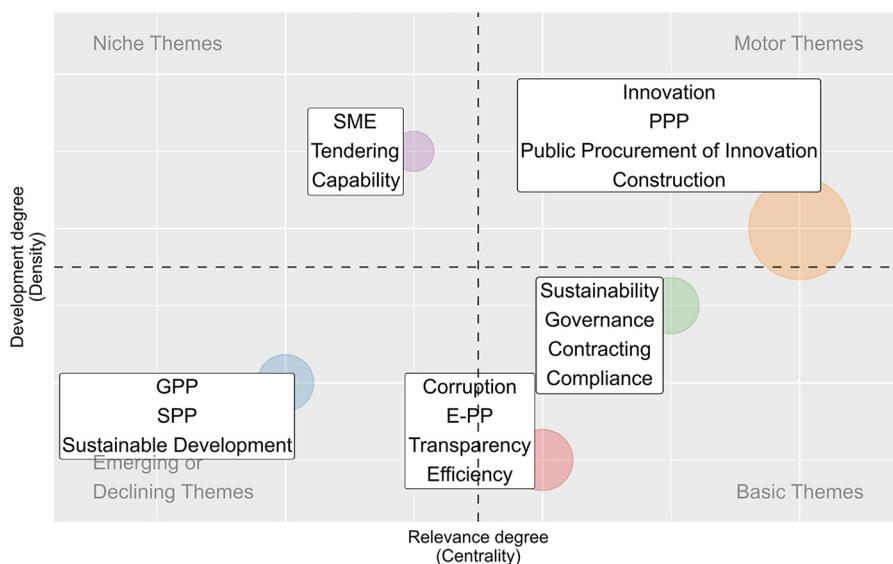


Figure 13.
Thematic map in PP
research

4. Future research directions

Based on the findings of the keyword co-occurrence network and topic modelling, this review suggests several directions for future research:

- This study demonstrates that mainstream research on PP has mainly focused on the role of PP in improving innovation activities. For example, [Blind *et al.* \(2020\)](#) argue that PP of innovation enables organisations to improve their export potential and increase the effectiveness and efficiency of delivering products and services to public authorities. [Zhang and Xu \(2021\)](#) also highlight that innovativeness in PP can contribute to the development of new services and technologies and the improvement of management and work practices. While the theme of innovation has received significant attention in the PP literature, the barriers and management issues related to PP for innovation are relatively under studied ([Caloghirou *et al.*, 2016](#)). As a result, future studies should examine the link between the benefits and barriers to innovation. Quantitative research aiming at exploring the link between innovation and PP is required to identify the nature of the relationship between innovative performances and procurement activities ([Caravella and Crespi, 2021](#)). The previous literature disregards the anticipated beneficial consequences of the new process of promoting the innovative capacities of suppliers or upgrading the public infrastructure. Furthermore, academics are hampered in their efforts to systematically advance state-of-the-art understanding of innovation in PP because of the conceptual interconnection across the many disciplines and the vagueness of important ideas in the area ([Obwegeser and Müller, 2018](#)).
- PP activities provide a fertile ground for corruption ([Basheka, 2009](#)). In this regard, [Neupane *et al.* \(2014\)](#) point out that PP processes are rife with corruption and fraud, especially in procurement planning, tender processes, project documentation, contract award and execution and accounting and auditing. Similarly, [Gottschalk and Smith \(2016\)](#) stress that despite the plethora of procedures and policies used by most public organisations to safeguard the stewardship of public funds, PP seems to be especially susceptible to corruption. Future studies are required to examine the role of ethics in combating corruption and add to the PP literature that has previously explored the mechanisms that establish the PP professional subject ([Cooper and Marder, 2022](#); [Montalbán-Domingo *et al.*, 2018](#); [Sargiacomo *et al.*, 2015](#)). Even though there is an increased reliance on private organisations in PP ([Keränen, 2017](#)), little is known about the ethical consequences of this trend in the academic literature ([Hawkins *et al.*, 2011](#)). While concerns have been voiced in relation to corruption from the demand perspective (government), the supply perspective has garnered less attention ([Sikka and Lehman, 2015](#)). Thus, increased attention is needed to develop effective mechanisms that increase the transparency of PP processes and easily detect fraud and potential opportunism ([Afolabi *et al.*, 2020](#)). Moreover, a pending research question is how the adoption of emerging technologies (e.g. big data analytics, blockchain technology and artificial intelligence) can serve as a tool to curb fraudulent practices in PP ([Ahmad *et al.*, 2021](#)), reduce process inefficiencies ([Velasco *et al.*, 2021](#)) and anticipate problematic PP contracts ([Gallego *et al.*, 2021](#)). As a result, future studies on the impact of modern technology-enabled PP on efficiency and corruption levels are necessary to enable competitive tendering processes, increase transparency and establish accountability for PP decisions ([Knack *et al.*, 2019](#)).

- Substantial research has been conducted on GPP and SPP as tools to achieve economic, social and environmental sustainability. However, little research has been devoted to investigating the utility of circular PP. While public tendering and procurement are beginning to adapt to the principles of the circular economy, this process is still in its infancy (Sönnichsen and Clement, 2020). Therefore, future studies should shed light on how circular PP can be a significant impetus for not only environmental and ecological innovation but also for overcoming the existing lack of support for innovation by the private and public sectors (Ntsondé and Aggeri, 2021). Because PP is not a discrete activity limited to the procurement department, the complexity of PP processes seems to rise while transitioning from GPP and SPP to circular PP. According to Sönnichsen and Clement (2020), circular PP is the process by which governments acquire products and services with the goal of developing closed material and energy loops and reducing or eliminating their negative effects on the environment and the generation of waste over their entire lifecycle. The research is still divided about how much of an effect circular PP has on fostering green market development and sustainable innovation. However, studies have shown that it might be challenging for local authorities to encourage public sector innovation by means of circular PP. Aldenius and Khan (2017), for example, draw attention to the challenges encountered by local authorities that want to stimulate innovation in certain technologies but lack comprehensive specifications of the functional requirements needed. Some academics even argue that circular PP is ineffective at its stated goal of fostering sustainable markets (Lundberg *et al.*, 2015). They argue that private enterprises will not modify their methods and instead create specialised goods for public markets, resulting in adverse environmental impacts even though circular PP can drive public parties to boost their consumption of sustainable and environmentally-friendly products and services. As a result, Cheng *et al.* (2018) draw the conclusion that there is a lack of evidence of the possible influence of circular PP on markets and innovation from their analysis of the literature on circular PP. Thus, future research should analyse how the implementation of this procurement type can impact supply chain configurations and stakeholder involvement and imply new responsibilities for various ecosystem players. Additional research is also needed to study the process of incorporating circular economy principles into PP, the barriers to circular PP implementation and the collaborative approaches necessary for the success of GPP and circular PP.
- Related to PP contracts, there are a few studies on the factors that impact the success of organisations in receiving PP contracts (Blind *et al.*, 2020). For example, it has been shown that firm innovation or the ability to offer innovation is a success factor for many organisations winning PP contracts (Georghiou *et al.*, 2014). Furthermore, researchers should investigate the relationship between organisations' CSR efforts and their capacity to gain PP contracts (Kaddouri and Saussier, 2022). This is crucial as prior studies show that organisations with higher CSR receive more PP contracts and that CSR can alleviate information asymmetries and signal trustworthiness (Flammer, 2018). As infrastructure contracts are not fully fleshed out organisations are enticed to submit lower-than-usual bids and attempt to renegotiate terms after being awarded the contract (Bosio *et al.*, 2022; Coviello and Mariniello, 2014; Decarolis and Palumbo, 2015). For PPPs, contract negotiation expenses are not restricted to the pre-delivery stage since renegotiation is often required for contracts that last several decades (Ahadzi and Bowles, 2004). Bidders

are deterred by the exorbitant entry fee, which is a clear barrier to entry. As a result, there is less initial competition among potential PPP contractors, leading to more market concentration (Carbonara and Pellegrino, 2018; Wan, 2014). However, the regularity of contract renegotiation can offer concessions a relational quality (Spiller, 2009) since contracts need to adjust to unanticipated circumstances. Therefore, it is of critical importance to determine whether or not renegotiations in PPPs are opportunistic requirements by one of the parties or mutually beneficial advances towards improved efficiency.

- SMEs are generally underrepresented in PP markets despite their critical role in national economies in terms of employment opportunities, innovation and contribution to national GDP. While the literature assessing the efficacy of policy interventions to aid SMEs in PP is expanding quickly (Reis and Cabral, 2015), the organisational capacities necessary to maximise the advantages of using these policy initiatives have received little critical attention. The importance of SMEs in PP has been discussed extensively in recent scholarly works (Chien *et al.*, 2021; Patil, 2017; Torres-Prüñonosa *et al.*, 2021). However, the impact of SMEs' involvement in international purchases has received scant research attention (Namagembe *et al.*, 2021; Saastamoinen *et al.*, 2018). For SMEs to be competitive in the market, they must work around obstacles that reduce their efficiency and ability to secure contracts. Consequently, there is a need to inspect the capabilities necessary to enhance SME involvement in PP (Akenroye *et al.*, 2020; Fayos *et al.*, 2022). Future studies should also examine how policies and regulations can encourage or hinder the participation of SMEs in PP. Since SMEs are often seen to be more dynamic and innovative than large enterprises, SME-friendly PP can thus encourage entrepreneurship and boost innovation (Knutsson and Thomasson, 2014). Moreover, researchers should assess the benefits of having SMEs as suppliers in PP and the challenges they face in responding to the needs of public sector actors (Karjalainen and Kempainen, 2008).

5. Conclusions, implications and limitations

This work was conducted to examine the scope and intellectual structure of PP research over the past four decades. Applying bibliometric techniques, 640 PP-related publications written by 1,247 authors were carefully analysed. In contrast to subjective approaches, bibliometric techniques can objectively chart an entire scientific domain as a random choice of evidence is not totally illustrative of the current state of research and the choice of certain publications over others results in a bias (Linnenluecke *et al.*, 2020). Therefore, the general landscape of academic publications concerning PP is revealed via the use of bibliometric analysis. To the authors' best knowledge, this is the first research to investigate the bibliometric profile of PP. In this comprehensive analysis, we revealed the main trends, the most productive authors and the most prolific journals in PP research. More specifically, we discovered that the majority of networks studied exhibit a hub-and-spoke typology (Watts and Strogatz, 1998). Therefore, it appears that PP research is mostly advanced by a small number of prominent scholars or academic organisations who control the field. Such scholars or institutions can be considered information brokers (Rosas *et al.*, 2011). Small world networks have the potential to pass knowledge more smoothly (Shirky, 2008) since the random elimination of nodes from the network will not materially affect the network dynamics and effectiveness (Smith and Graham, 2019).

According to the study's findings, research articles on PP networks seem to adhere to the well-known Matthew Effect. As such, this effect is comparable to the preferential attachment process, wherein a minority of actors compose the network's core. This phenomenon is referred to as the power-law mechanism (Himmelboim *et al.*, 2013), that is, a version of the rich-get-richer scenario in which a limited handful of scholars or academic institutions constitute the core of the cluster. Several other knowledge fields have also observed this phenomenon, including diseases, sexual relationships, citations in academic works and the World Wide Web (Himmelboim and Han, 2014).

It is interesting to observe how research collaboration between countries and academic institutions is governed by factors like geographical distance and cultural closeness. This result confirms the conclusions of some scholars who examined the cooperation patterns among researchers (Prieto-Gutiérrez and Segado-Boj, 2019). Consistent with previous studies, we observe that universities are the primary source of PP-related publications, followed by research institutes, such as Centre National de la Recherche Scientifique and the World Bank. Furthermore, limited collaboration between developed and developing countries in PP research was also noticed in other knowledge fields (Vanni *et al.*, 2014). Regarding the conceptual structure of PP research, the keyword co-occurrence network analysis reveals that innovation, corruption, SPP, GPP, PP contracts, PPP and SME involvement in PP attract significant attention from researchers. In other words, the public sector is increasingly obligated to consider innovation, environmental concerns and proper PP practices in all phases of procurement to disseminate innovations, create sustainable products and increase compliance. Also, of major importance to scholars is the need to prevent corruption, promote transparency and guarantee effective governance in PP. Furthermore, the existing literature corpus is highly developed to offer knowledge of the dynamic, complex and ever-changing relationships in the context of PPP (Sharma *et al.*, 2019; Wang *et al.*, 2019). Because of their proven track record of delivering quality, innovation, efficiency, funding, expertise and, most crucially, risk sharing to developed and intricate projects, PPPs have risen to prominence as a framework for procuring public works worldwide (Rouboutsos and Saussier, 2014). As a result, PPPs are anticipated to maximise the gains sought after project developments, assisting governments in establishing infrastructure, delivering high-quality services and promoting greater asset utilisation and innovation (Carbonara and Pellegrino, 2018; Essig and Batran, 2005).

This research offers scholars and practitioners several implications and insights. The paper provides a detailed bibliometric analysis that identifies, systematises and explores crucial aspects of the PP field and emphasises the need for future research. The present study objectively reports the research performance results concerning PP by identifying the most relevant journals, scholars, nations, academic institutions and relevant themes. The article enriches the current PP literature and contributes to its historical formation, increasing the practitioners' understanding of the core themes discussed in this domain. The review results are useful for researchers to gain a better understanding of the worldwide research conducted on PP and its distribution across researchers, journals, nations and academic institutes. Furthermore, it aids scholars in comprehending the roots, development and current state of the PP field, as well as identifying the most relevant trends and prospective research avenues.

Based on the research findings and discussions, several suggestions for future policy actions emerge from our investigation of the data. Firstly, governments should be engaged in seeking new public procurement innovation (PPI) policies to implement so that PP can better facilitate innovation in all industries. It is also imperative for governments to rethink their policies for PPI in light of inherent contradictions between future innovation needs and

short-term gains. Secondly, PP is an incentive-based tool for influencing the content and structure of supply. Managers in the public sector must strike a balance between the economic, environmental and social aspects of procurement to provide sufficient incentives to the supply market. SPP has economic, environmental and social impacts that should all be taken into account by policymakers. It is crucial for organisations to have a strategic approach to both GPP and SPP if they want to maintain their competitive edge while also helping to accomplish environmental and social objectives via PP. Organisations in the private sector stand to gain in a number of ways, including cost savings, enhanced capacity for risk management and innovativeness. As a result organisations should be rewarded for their efforts to help achieve policy goals to better predict the social and environmental conditions necessary to achieve GPP and SPP goals. Thirdly, policymakers should prioritise anti-corruptions efforts to eliminate potential entrance or participation constraints and increase the number of bidders in the PP process. Fourthly, state and local governments should devise policies to encourage the establishment of effective networking capabilities between SMEs and other players in PP processes.

Despite its considerable contributions, this research has a few flaws. Firstly, an example of a possible limitation is our sample selection strategy. We performed a topic search (title, abstract and keywords fields) to generate a representative sample and increase specificity. This strategy may have omitted some relevant articles, particularly those published in *Journal of Public Procurement (JoPP)* and not including the terms of the search string used for this review. However, the inclusion of all publications of this journal, regardless of whether the keywords occur in the search fields, is a bias in favour of *JoPP*. As a result, we believe that starting with a collection of a priori and appropriate keywords is the foundation of every systematic search strategy (Agrawal *et al.*, 2022; Hamid *et al.*, 2021). Similarly, we think that we were able to reliably infer trends in PP research because our sample size was large enough to be broadly representative. Thus, our findings reveal patterns of PP research rather than serving as an exhaustive and complete inventory of all PP research.

Secondly, the search keywords used to retrieve the publications were based on the prior literature. Thus, any additional keywords (e.g. government contracts, contracting) may maximise the inclusion of all potentially pertinent publications related to PP and result in novel insights that expand the field's rising trends. Additionally, searching just Scopus could have impacted the results to some extent; nonetheless, we believe that, given the objectives of the current review, there is minimal merit to employing numerous databases in the bibliometric analysis. Consequently, future studies can improve upon this work by using different academic databases, such as the WoS, and comparing the findings to this study's results. Thirdly, while techniques such as topic modelling allow for comprehensive coverage of a broad range of publications, they still fall short of human reviewers in terms of accuracy in content analysis and interpretation. They determine the links between texts based on keyword co-occurrence and primary themes according to word frequency. As a result, additional content and text analysis techniques can be applied in future research to detect topics and distinguish between themes in PP research conclusively. Finally, any journal-specific bibliometric analysis and topic modelling dealing with the PP field (e.g. *JoPP*, *International Journal of Procurement Management*) is welcome to evaluate research output, trends and impact.

Note

1. The full list of the 640 publications analysed in this work can be obtained from the first author upon request.

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