ISSN: 2599-1086 | e-ISSN: 2656-1778 | Vol. 7 | No. 1

Exploring Risk Aspects in Public-Private Partnership Infrastructure Research: A Bibliometric Analysis

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ABSTRACT

The risk aspect is a key component of the Public-Private Partnership (PPP) infrastructure scheme. The study employed bibliometric analysis to shed light on research trends concerning risk aspects in PPP. The author focused on publication trends, co-authorship networks, local citation patterns, cluster analysis, and co-occurrence of key terms. In addition, the authors compiled a list of studies on the risk aspects of PPP infrastructure. Using bibliometric data from 356 Scopus-indexed publications, this study identifies the leading authors, nations, institutions, publishers, influential papers, and research topics related PPP infrastructure risk over the past decade (2014-2023). The findings reveal that from 2014 to 2017, research predominantly focused on risk factors, success criteria, development projects, contracts, toll roads, water supply, and social infrastructure. Between 2018 and 2020, the emphasis shifted towards risk assessment, risk analysis, risk management, and risk allocation. Since 2021, the research trends have evolved to include urban growth, investment, the private sector, partnership models, internet protocols, and intelligent systems. Future research on PPP infrastructure risk should incorporate technological concepts and business entity perspectives. This study also contextualizes its findings within the broader landscape of emerging markets in Asia and globally and highlights these trends in the Indonesian context.

Keywords: Bibliometric analysis; Infrastructure; PPP; Risk aspects

ABSTRAK

Aspek risiko merupakan elemen penting dalam skema KPBU infrastruktur. Penelitian ini mencoba menginventarisasi kajian-kajian mengenai aspek risiko infrastruktur KPBU melalui analisis bibliometrik. Peneliti berfokus pada tren publikasi, *co-authorship*, pola kutipan (lokal), analisis klaster, dan penggunaan istilah-istilah kunci dari 356 artikel terindeksasi Scopus. Peneliti mengidentifikasi para penulis, negara, institusi, penerbit, artikel, dan topik penelitian terkemuka mengenai aspek risiko infrastruktur KPBU dalam satu dekade terakhir (2014-2023). Temuan penelitian ini menunjukkan bahwa sejak tahun 2014 hingga 2017 sebagian besar kajian berfokus pada faktor risiko, kriteria keberhasilan, proyek pembangunan, kontrak, jalan tol, pasokan air, dan infrastruktur sosial. Antara tahun 2018 dan 2020 penelitian banyak mengkaji penilaian risiko, analisis risiko, manajemen risiko, dan alokasi risiko. Sejak 2021, tren penelitan bergeser pada pertumbuhan perkotaan, investasi, sektor swasta, model kemitraan, *internet protocol*, dan sistem cerdas. Penelitian terkait risiko ke depan sebaiknya memiliki pembaharuan dengan memasukkan konsep teknologi dan sudut pandang badan usaha dalam kerangka skema infrastruktur KPBU. Penelitian ini juga mengkontekstualisasi temuan dengan lanskap yang lebih luas di pasar-pasar baru Asia dan dunia sebagai bahan perbandingan dengan tren penelitian di Indonesia.

Kata Kunci: Aspek-aspek risiko; Bibliometrik; Infrastruktur; KPBU

ARTICLE HISTORY

Received: May 8, 2024
Revised: June 11, 2024
Published: June 30, 2024

CITATION (APA 7TH)

Sunandar, A., Karim, S. B. A., & Zolkafli, U. K. (2024). Exploring Risk Aspects in Public-Private Partnership Infrastructure Research: A Bibliometric Analysis. *Journal of Infrastructure Policy and Management, 7*(1), 27–41.

INTRODUCTION

In recent decades, risk has been an important feature of research in Public-Private Partnership (PPP) infrastructure. It has transformed into a more attractive and most-researched topic worldwide. Some studies suggest that the benefits of risk aspects include enhancing the recovery rate for lenders and their predicted loss (Zapata Quimbayo & Mejía Vega, 2023), monitoring the schedule of construction phase (Akhtar et al., 2023; Putri et al., 2023), and managing the smooth implementation of PPP projects (Chen et al., 2023; Chiang et al., 2022; Feng et al., 2021; Moradi Shahdadi et al., 2023). Other relevant research elucidates prominent positive views as studying the risk of PPP to become the key factor of PPP's success (Fathi & Shrestha, 2023; Lima et al., 2023; Ramli et al., 2021), enhance the resilience of PPP (Li & Wang, 2023), investigate common risk allocation in middle-income nations vs. low-income ones (Kouton et al., 2023), evaluate PPP projects (Jokar et al., 2023), attract business environment (Belghiti & Angade, 2023; Tamošaitienė et al., 2021), and promote sustainable infrastructure development (Braeckman et al., 2022; Khahro et al., 2021; Mazher et al., 2022).

In addition to the mentioned benefits, some scholars share similar notions regarding the benefits of risk aspects such as making decisions on PPP project investments (Amiri et al., 2022; Dorfeshan et al., 2022; Fan et al., 2022; Geng et al., 2022; Sumrit, 2021; Sun et al., 2023), providing technical, guide, and reference support (Hartono et al., 2021; Zhai et al., 2021; Zhang et al., 2021; Zhang et al., 2021), achieving smooth transfer phase (Bao et al., 2022), reaping financial and operating benefits (Sidorenko et al., 2021) and improving project resilience (Liyanage & Villalba-Romero, 2021).

This research attempts to complement previous studies concerning the topic of risk aspects in the PPP scheme by mapping its trend using bibliometric techniques. The articles included in this study were generated from reputable articles indexed by Scopus with a more recent year range, from 2014 to 2023. The research findings are expected to inspire the development of the risk aspects in the PPP-related studies and see whether Indonesia (both in terms of researchers, research topics, organizations, and sponsors) is included in the top ranks of research. The perspective employed in this study helps to set the groundwork for PPP infrastructure by understanding the present risk component as extracted from innovative studies in the literature.

This study tries to highlight grey areas that demand quick attention from professionals by categorizing blank lines that influence risk characteristics contributing to the

formulation of PPP infrastructure policies. This study may help to generate guidance for practitioners by incorporating characteristics of several studies that affect PPP infrastructure risks. Finally, the study employs rigorous scientific approaches to investigate the prevalent research trends linked to PPP infrastructure risk, thereby providing fresh references for future research and identifying an emerging research agenda for PPP infrastructure risk.

To meet the research aims, this study employed bibliometric analysis, i.e., an assessment of the bibliographic information of published scientific materials by statistical techniques following qualitative and quantitative indices that combine bibliographic mapping, publication profiling, clustering, and visualizing (Ali et al., 2023; Donthu et al., 2021; Kumar et al., 2021; Sholihin et al., 2021).

THEORETICAL FRAMEWORK

Public-Private Partnership (PPP) is one of many options for financing public infrastructure development. PPPs have broadened the restricted list of public project financing options available to the authorities, due in part to their low-cost encouragement of economic development and social welfare optimization. PPPs are based on the idea that the private industry, with its advanced technological and management abilities, is better capable of producing higher-quality products than the government (Chen et al., 2023; Chiang et al., 2022; Feng et al., 2021; Kouton et al., 2023; Moradi Shahdadi et al., 2023).

Generally, risks associated with PPP projects will be recognized, exchanged, and negotiated throughout the contract-making cycle. In the context of future collaboration, the joint structuring of contract components, including sharing of risk, reward delivery, and execution of projects between both the public and the private industry, is a transparent form (Chen et al., 2023; Fathi & Shrestha, 2023; Lima et al., 2023; Ramli et al., 2021; Sunandar & Indiyati, 2023).

Risk, as its name suggests, refers to a state of uncertainty and, unfortunately, the majority of risks will often result in unintended losses. Risk analysis is essential for a company to minimize losses. Risk analysis seeks to detect the likelihood of a firm's profit or loss. Construction, operation, finance, trade, and politics are common categories of risks. Financial risks arise due to inaccurate assumptions about the rates of inflation, interest fluctuation, and currencies. Construction risks include unanticipated and unplanned delays and expenditures. Meanwhile, operational risk is an accident and vandalism that produces damages. Commercial hazards arise as a result of incorrect cost or traffic volume projections (Lima et al., 2023; Putri et al., 2023).

PPP projects are risky because of the large number of participating parties, the long agreement period, and the intricacies of legal contracts. Recent research on PPP projects focuses on identifying risks, assessments, and allocation (Sun et al., 2023). In terms of risk identification, various scholars have conducted research on the risks of PPP (Fathi & Shrestha, 2023; Li & Wang, 2023; Moradi Shahdadi et al., 2023; Pai et al., 2018; Shams Eldin et al., 2019; Sun et al., 2023). Regarding assessment of risk, the proposed risk analysis framework is based on criteria for assessment and relevant project knowledge to assess all of the risk (Ameyaw & Chan, 2015; Ameyaw & Chan, 2015; Belghiti & Angade, 2023; Chen et al., 2023; Nguyen et al., 2018; Sun et al., 2023; Tamošaitienė et al., 2021).

Risk allocation is a primary concern among risk-reduction actors: government agency, business industry, or a combination of both. Risk must be allocated to the appropriate parties, who may determine the likelihood of risk, manage the consequences of risk occurrence, and bear the risk at the lowest risk cost. Risks in critical categories or levels must be addressed by the appropriate parties to ensure that risk management runs as needed (Jokar et al., 2023; Kouton et al., 2023; Putri et al., 2023; Selim et al., 2019).

The theoretical framework of the risk aspects in the PPP process is summarized in Figure 1.

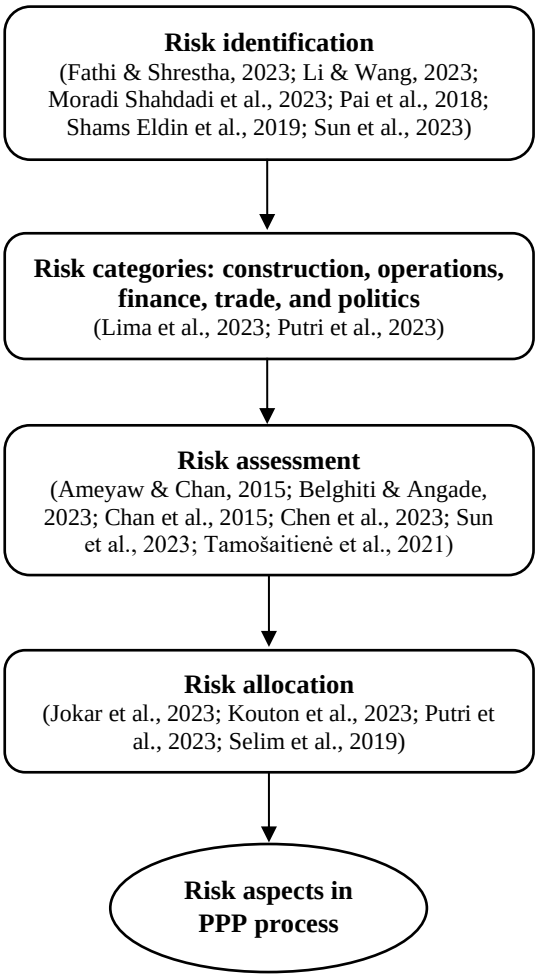

Figure 1. Theoretical framework
Source: Author's figure (2024)

METHODOLOGY

To achieve the objectives, the authors use a bibliometric analysis technique to determine the best-suited research themes regarding the risk aspects of PPP infrastructure. In the last decade, this study complements risk aspects of the PPP scheme by mapping its development using bibliometric techniques by focusing on reputable articles indexed by Scopus between 2014 and 2023. We expect that we can understand the development of the research focus on risk aspects in the PPP scheme and see whether Indonesia (both in terms of researchers, research topics, organizations, and research sponsors) is included in the top ranks of research. This assumption is supported by conducting a Scopus search for "risk PPP infrastructure" between 2014 and 2023. The authors' institutional subscription allowed them to access the study contents. Journals indexed by Scopus are mostly reputable because those listed in this database must adhere to strict indexing requirements and it is frequently suggested for bibliometric analysis.

Figure 1 illustrates the three-phase process of selecting studies for bibliometric analysis. The first phase was an indexing search that began in early May 2024 to prioritize all possible Scopus papers issued between 2014 and 2023 that contained "risk PPP infrastructure" keywords in the article's title or abstract. The phase generated 579 results. Then, the authors decided on and confirmed the phrases used to find papers relevant to this study. The second phase was filtration, in which papers were included for bibliometric analysis. The authors selected published articles rigorously by journals and preserved articles based on the English language because some studies were published in languages other than English, which hindered the authors from reviewing big data sets. As a result, 223 articles were

eliminated and 356 articles were kept. The 356 articles were screened for bibliometric review in the third phase of this search technique. The finalized papers were processed for bibliometric analysis, which was discussed in sections 4 and 5.

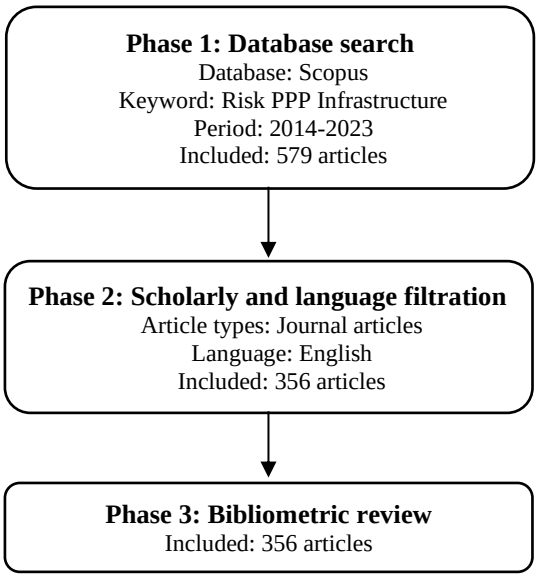

Figure 2. Bibliometric review approach
Source: Author's creation (2024)

Figure 2 explains the evaluation carried out in bibliometric analysis of the risk aspects in PPP infrastructure literature. The 356 shortlisted articles (retrieved from Scopus) were subjected to different bibliometric studies. Scholars were particularly interested in undertaking publishing, global citation, and cluster analyses to investigate publication trends, top contributors (authors, institutional affiliations, and nations), and main publishers (outlets and publications) of PPP infrastructure risk.

FINDINGS

The authors formulated and discussed the findings concerning bibliometric features and research themes by linking them with the risk components of PPP infrastructure research.

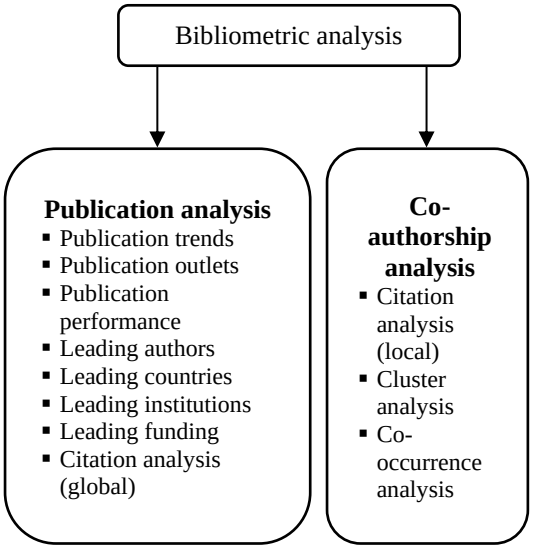

Figure 3. Bibliometric review analysis strategy
Source: Author's creation (2024)

Publication Trend

The allocation of papers by their year of publication implies that the risk factor in PPP infrastructure has experienced a surge in scholarly interest during the previous decade (see Figure 3). The majority of research was published in 2019 (n=53). Interestingly, the risk factors in PPP infrastructure research increased by double digits every year from 2014 to 2023, which can be linked to the expansion of accelerated infrastructure development in many nations during the last decade.

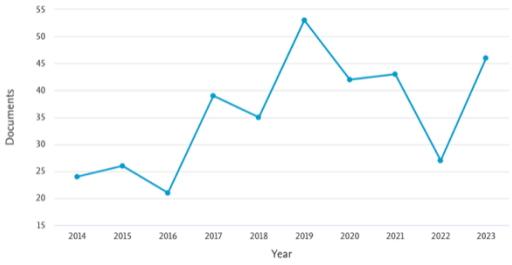

Figure 4. Research publication trend from 2014 to 2023
Source: Authors' creation (2024)

Publication Outlet

The allocation of publications by publication outlets demonstrates that the *Journal of Construction Engineering and Management* is an especially productive source for risk aspects in PPP infrastructure research (n=14) (see Table 1). *Sustainability*, *Journal of Management in Engineering*, and *Management Journal of Infrastructure Systems* follow the trend, with 13, 9, and 8 articles on risks in PPP infrastructure research, respectively. The majority of publication sources on this list are journals classified in the Q1 journal impact quartile by SJR, indicating that the risk factors of PPP infrastructure research are valued at top-tier journals.

Table 1. Top journals contributing to the research
Source: Authors' creation (2024)

Journal title	No. of articles	Journal impact quartile
Journal of Construction Engineering and Management	14	Q1
Sustainability	13	Q1
Journal of Management in Engineering	9	Q1
Journal of Infrastructure Systems	8	Q2
Built Environment Project and Asset Management	7	Q1
International Journal of Project Management	7	Q1
Construction Management and Economics	6	Q1
Engineering Construction and Architectural Management	6	Q1
International Journal of Civil Engineering and Technology	6	-
International Journal of Strategic Property Management	6	Q3

Global Citations

Global citations are the total amount of citations acquired without any filtering (for example, by discipline). In this analysis, the paper with the highest global citations is "Public-private partnership in public administration discipline: A literature review" (n=272 citations), followed by "Cross-country comparisons of key drivers, critical success factors, and risk allocation for public-private partnership projects" (n=222 citations) (see Table 2).

Table 2. Top ten papers with the most global citations according to Scopus
Source: Authors' creation (2024)

Rank	Article title	Author (Year)	Citation
1	Public-private partnership in public administration discipline: A literature review	Wang et al. (2018)	272
2	Cross-country comparisons of key drivers, critical success factors, and risk allocation for public-private partnership projects	Chou & Pramudawardhani (2015)	222
3	Evaluation and ranking of risk factors in public-private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach	Ameyaw & Chan (2015)	185
4	Concession period for PPPs: A win-win model for a fair risk-sharing	Carbonara et al. (2014)	146

Rank	Article title	Author (Year)	Citation
5	Conceptual framework for the performance measurement of public-private partnerships	Liu et al. (2015)	119
6	Cross-sectional analysis of critical risk factors for PPP water projects in China	Chan et al. (2015)	116
7	Financial risk assessment and modeling of PPP-based Indian highway infrastructure projects	Kumar et al. (2018)	109
8	Bibliometric Analysis of PPP and PFI literature: Overview of 25 years of research	De Castro E Silva Neto et al. (2016)	98
9	Critical risk factors affecting the implementation of PPP waste-to-energy projects in China	Xu et al. (2015)	93
10	Risk ranking and analysis in PPP water supply infrastructure projects	E. E. Ameyaw & A. P. Chan (2015)	91

Leading Authors

The ranking of publications by authors reveals that Chan, A. P. C. from the Hong Kong Polytechnic University, Hong Kong, and Ameyaw, E. E. from the University of Northumbria, Newcastle, UK have published the most articles on the risk components of PPP infrastructure (n=6 articles) (see Table 3). The authors who contributed the second and third most publications on the risk component of PPP infrastructure are Marques, R. C. (n=5 articles), and Xiong, W. and Liu, J. (n=4 articles), respectively.

Table 3. Top contributing authors to the research
Source: Authors' creation (2024)

Author	Affiliation	Number of articles
Chan, A. P. C.	The Hong Kong Polytechnic University, Hong Kong	6
Ameyaw, E. E.	University of Northumbria, Newcastle, United Kingdom	6
Marques, R. C.	Lusófona University, Lisbon, Portugal	5
Xiong, W.	Tongji University, Shanghai, China	4
Liu, J.	Southwest Jiaotong University, Chengdu, China	4
Osei-Kyei, R.	Western Sydney University, Penrith, Australia	3
Aminnejad, B.	Islamic Azad University, Tehran, Iran	3
Bilal, M.	Atlantic Technological University, Killybegs, Ireland	3
Chan, D. W. M.	The Hong Kong Polytechnic University, Hong Kong	3
Jagboro, G. O.	Obafemi Awolowo University, Ife, Nigeria	3

Leading Countries

The ranking of papers by country indicates that authors from 68 countries contributed and published studies on the risk aspects of PPP infrastructure. According to the country-by-country analysis, China

contributes the most to research (72 articles), followed by Australia (43 articles), the United States (36 articles), and the United Kingdom (30 items). In Asia, behind China, India is the second largest contributor to research (29 papers), followed by Hong Kong (19 articles), Iran (13 articles), and Malaysia (13 articles) (See Figure 4).

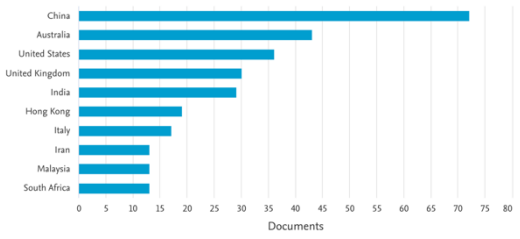

Figure 5. Top 10 leading countries
Source: Authors' creation (2024)

Institutions

The distribution of articles by institution shows that the Hong Kong Polytechnic University in Hong Kong is the leading university contributing to the risk aspects of PPP infrastructure focus (n=16) (see Figure 5). The table also includes Instituto Superior Técnico and Universidade de Lisboa in Portugal (n=8 articles), the University of Johannesburg in South Africa, Dalian University of Technology and Tongji University in China, and Obafemi Awolowo University in Nigeria; each of which contributes 7 articles.

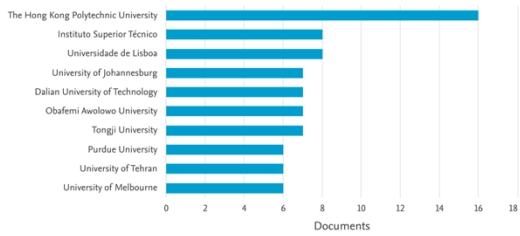

Figure 6. Top 10 leading institutions
Source: Authors' creation (2024)

Leading Funding Sponsor

The distribution of publications by funding sponsor shows that the National Natural Science Foundation of China is the leading and generous sponsor for risk-related PPP infrastructure research (32 articles) (see Figure 6). This is followed by Fundamental Research Funds for Central Universities (10 articles), European Regional Development Fund, and Hong Kong Polytechnic University; each has 5 articles.

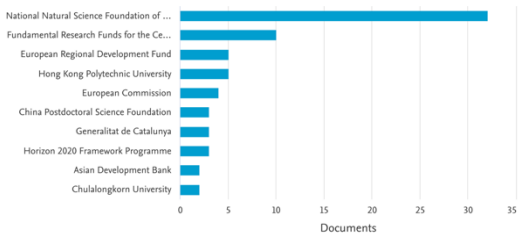

Figure 7. Top 10 leading funding sponsor
Source: Authors' creation (2024)

Topics or Themes

A co-occurrence study was conducted using every keyword from 356 articles in VOSviewer to uncover the subjects that can reflect a desire for the risk aspects of PPP infrastructure studies (see Figure 7). In this concept, keywords represent the article's focus. More importantly, the co-occurrence of keywords is important in the development of knowledge as a domain's intellectual framework, specifically the subjects in the intellectual structure of risks in PPP infrastructure as viewed through a regular lens.

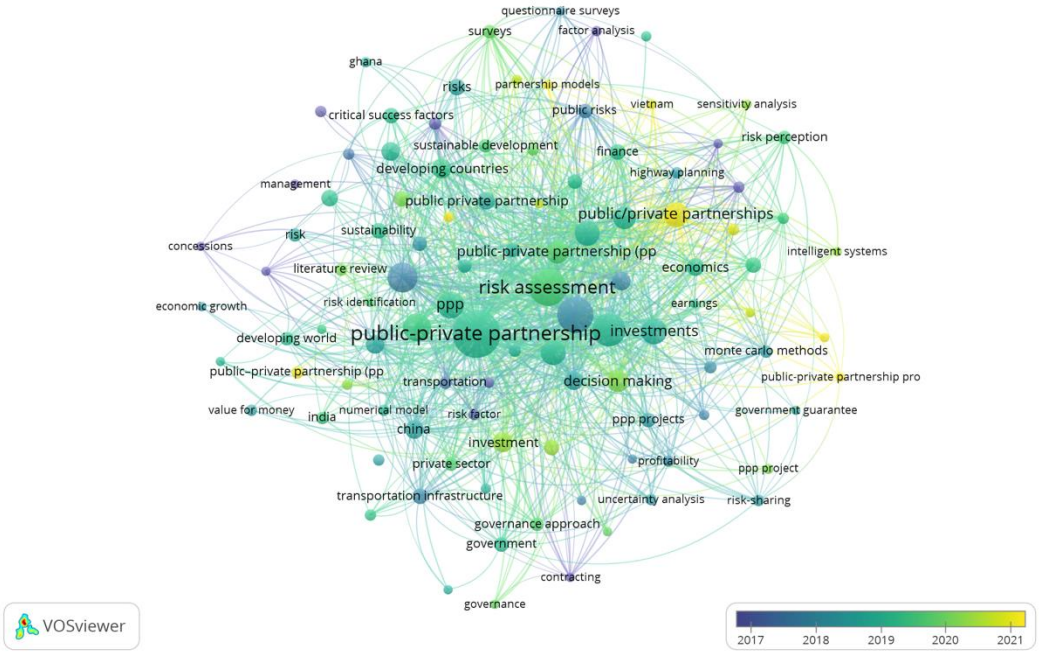

Figure 8. Research theme risk aspect in PPP infrastructure
Source: Authors' creation (2024)

DISCUSSION

Risk aspects in PPP infrastructure have been recently analyzed by scholars globally from diverse perspectives, with different methods, and on a variety of sectors, including toll roads and freeway (Fathi & Shrestha, 2023; Jokar et al., 2021, 2023; Putri et al., 2023; Zapata Quimbayo & Mejía Vega, 2023), urban rail (city) transit (Feng et al., 2021; Sun et al., 2023), water infrastructure (Amiri et al., 2022; Bao et al., 2022; Lima et al., 2023; Moradi Shahdadi et al., 2023; Y. Zhang et al., 2021), wastewater infrastructure (Amiri et al., 2022; Moradi Shahdadi et al., 2023), energy infrastructure (Kouton et al., 2023), sludge treatment (Fan et al., 2022), social housing (Chiang et al., 2022), hydropower facilities (Braeckman et al., 2022), seaport (Liyanage & Villalba-Romero, 2021; Sumrit, 2021), and electricity infrastructure (Hartono et al., 2021).

Many methodologies are now employed for risk analysis in PPP infrastructure. For quantitative approaches, they include the Monte Carlo simulation technique (Zapata Quimbayo & Mejía Vega, 2023), system dynamics approach (Sun et al., 2023), fuzzy multi-criteria (Dorfeshan et al., 2022; Feng et al., 2021; Jokar et al., 2021, 2023; Sumrit, 2021; Y. Zhang et al., 2021), and statistic or model approach (Belghiti & Angade, 2023; Chiang et al., 2022; Fan et al., 2022; Ramli et al., 2021). As for qualitative approaches, they cover Delphi technique (Fathi & Shrestha, 2023; Moradi Shahdadi et al., 2023; Tamošaitienė et al., 2021), semi-structured interviews (Akhtar et al., 2023), normative legal research (J. Zhang et al., 2021), and mixed method approach (Amiri et al., 2022; Bao et al., 2022; Chen et al., 2023; Hartono et al., 2021; Khahro et al., 2021; Li & Wang, 2023; Lima et al., 2023; Liyanage & Villalba-Romero, 2021; Mazher et al., 2022; Putri et al., 2023; Zhai et al., 2021).

Keyword co-occurrence network reveals a few remarkable trends. Studies on risk aspects in PPP infrastructure from 2014 to 2017 focused on PPP, risk factors, concessions, crucial success criteria, development projects, toll highways, water supplies, contracts, and social infrastructure. Between 2018 and 2020, the next wave of risk aspects in PPP infrastructure research centered on PPP, risk assessment, risk analysis, risk management, risk sharing, value for money, project management, merger and acquisition, infrastructure projects, investment, stakeholder, India, China, surveys, and governance. Since 2021, risk analysis in PPP infrastructure research has primarily focused on PPP, costs, urban growth, Vietnam, investment, partnership models, private sectors, private investment, internet protocols, and intelligent systems.

The ongoing research on risk aspects in PPP infrastructure focuses on current contextualized risks with technology such as internet protocols and intelligent systems within the PPP infrastructure framework. A great number of studies have also explored perspectives from the business sectors, such as investment, cooperation models, and costs. The common story fetishes research explains that risk assessment, risk analysis, risk sharing, and risk management were prominent subjects three to five years ago. Some studies have also linked countries such as China, India, and Vietnam to the risk factors in PPP infrastructure.

Our findings on top authors, countries, and institutions show that scholars and educational institutions do not have a dominant position in research on risk in PPP infrastructure. One probable explanation for this result is the availability of research funds, as well as the prominence of risks in PPP infrastructure as a top research trend among researchers and institutions.

This study examined the current literature for mapping the bibliometric characteristics and understanding the framework of the risk aspects in PPP infrastructure. The researcher was concerned with the main issues of authors, countries, institutions, financing, publication outlets, papers, and subjects of risk-related research in PPP infrastructure from 2014 to 2024. We focused specifically on leading authors, highly cited publications, and co-occurring keywords.

Some discussions of our bibliometric review are summarized below:

1. The research elements of PPP infrastructure show consistent growth, with the majority of publications being released within the recent year.

2. *Journal of Construction Engineering and Management* was the most popular publication outlet, followed by *Sustainability*, *Journal of Management in Engineering*, and *Journal of Infrastructure Systems* in the research on risk aspects in PPP infrastructure.

3. Chan, A. P. C. from the Hong Kong Polytechnic University, Hong Kong, and Ameyaw, E. E. from the University of Northumbria, Newcastle, United Kingdom were the top contributing authors.

4. Emerging markets like China, India, Malaysia, and South Africa lead the top 10 countries contributors, creating an opportunity for scholars to research on risk aspects in PPP infrastructure.

5. The articles authored by Wang et al. (2018) had the highest global citations, followed by Chou and Pramudawardhani (2015) and E. E. Ameyaw and A. P. C. Chan (2015).

For the Indonesian context, there are no categories related to the country in the top list categories of bibliometric analysis on risk aspects in PPP infrastructure from 2014 to 2023. Compared with other Asian emerging markets in Asia, China, Malaysia, Vietnam, and Iran are the 10 biggest countries that dominantly contributed and published research on risk aspects in PPP infrastructure. Apart from that, institutions in China (The Hong Kong Polytechnic University and Dalian University of Technology), Iran (University of Tehran), and Thailand (Chulalongkorn University) have invested in research and are included in the 10 leading funding sponsors regarding the topic. In terms of research objects, China, India, and Vietnam have become research topics for risk aspects in PPP infrastructure in the past decade. This also coincides with infrastructure development and economic growth in the three countries.

The risk aspects of PPP infrastructure are important factors to consider when developing infrastructure under the PPP scheme. Many stakeholders in Indonesia should conduct more in-depth research on the risk components of PPP infrastructure, including finance supports, prioritizations, and facility accesses. Finally, it is envisaged that Indonesia would become a global research reference and have a direct impact on infrastructure development through a sustainable PPP scheme that meets various stakeholders' attainment criteria.

CONCLUSION

The risk aspect is essential in PPP infrastructure since it may have a direct impact on the cost, income, and ease of the project. This bibliometric analysis of the literature allowed us to extract the bibliometric aspects and conceptual structure of this topic in existing studies, as well as identify future research themes to improve our comprehension of risk aspects in PPP infrastructure. The findings have demonstrated risk considerations must be employed as the main approach in infrastructure development, implementation, and operation instead of complementing analysis. Institutions that overlook risk aspects may have difficulties in creating and managing their primary infrastructure under the PPP scheme.

Our review also demonstrates the need for scholars to use a variety of approaches in addition to existing ones when analyzing relevant concerns. Computational tools based on machine learning, simulation, and mathematical modeling can bring novelty to the risk aspects of PPP infrastructure. Research on risk factors in PPP infrastructure utilizing a technological concept approach is similarly scarce. As a result, we encourage future research to be bolder and more original in developing risk elements in PPP infrastructure research by employing non-traditional approaches to examine risk aspects in diverse PPP infrastructure sectors.

To that end, the study of risk factors in PPP infrastructure will continue to be appealing to academics, practitioners, and policymakers as the business climate changes both domestically and internationally. There is also a need to investigate breaking down silos through improved collaboration among stakeholders from diverse countries and institutions. We are convinced that our recommendations and demands for increased collaboration in research on the risk aspects of PPP infrastructure are beneficial to players in the industry, especially in the context of infrastructure development in Indonesia. Through reputable research fields with a

focus on risk aspects in the PPP scheme, Indonesia (both in terms of researchers, research topics, organizations, and research sponsors) will be at the top of the risk aspect research ranking in PPP discourse and implementation. On the other hand, to get ahead of the existing trends, researchers or stakeholders in Indonesia should conduct research related to risk aspects in PPPs with a focus on conducting studies of novel themes such as risk aspects viewed from technological concepts and perspectives of business entities within the framework of the PPP scheme.

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REFERENCES

Akhtar, M., Mufti, N. A., Mubin, S., Saleem, M. Q., Zahoor, S., & Ullah, S. (2023). Identification of various execution modes and their respective risks for public-private partnership (PPP) infrastructure projects. *Buildings*, *13*(8). https://doi.org/10.3390/buildings13081889

Ali, Q., Parveen, S., Aspiranti, T., Nurhayati, N., & Rusgianto, S. (2023). Barriers to the adoption of Islamic banking: A bibliometric analysis. *International Journal of Ethics and Systems*. https://doi.org/10.1108/ijoes-01-2023-0001

Ameyaw, E. E., & Chan, A. P. (2015). Risk ranking and analysis in PPP water supply infrastructure projects. *Facilities*, *33*(7-8), 428–453. https://doi.org/10.1108/F-12-2013-0091

Ameyaw, E. E., & Chan, A. P. C. (2015). Evaluation and ranking of risk factors in public-private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach. *Expert Systems with Applications*, *42*(12), 5102–5116. https://doi.org/10.1016/j.eswa.2015.02.041

Amiri, O., Ayazi, A., Rahimi, M., & Khazaeni, G. (2022). Risks of water and wastewater PPP projects: An investors' perspective. *Construction Innovation*, *22*(4), 1104–1121. https://doi.org/10.1108/CI-04-2021-0073

Bao, F., Martek, I., Chen, C., Wu, Q., & Chan, A. P. C. (2022). Critical risks inherent to the transfer phase of public-private partnership water projects in China. *Journal of Management in Engineering*, *38*(3). https://doi.org/10.1061/(ASCE)ME.1943-5479.0001024

Belghiti, Z., & Angade, K. (2023). Risk assessment of public-private partnerships projects in developing countries. *International Journal of Critical Infrastructures*, *19*(2), 108–123. https://doi.org/10.1504/IJCIS.2023.130448

Braeckman, J. P., Markkanen, S., & Seega, N. (2022). Financiers' perceptions of risk in relation to large hydropower projects. *Environmental Research: Infrastructure and Sustainability*, *2*(1). https://doi.org/10.1088/2634-4505/ac4e70

Carbonara, N., Costantino, N., & Pellegrino, R. (2014). Concession period for PPPs: A win-win model for a fair risk sharing. *International Journal of Project Management*, *32*(7), 1223–1232. https://doi.org/10.1016/j.ijproman.2014.01.007

Chan, A. P. C., Lam, P. T. I., Wen, Y., Ameyaw, E. E., Wang, S., & Ke, Y. (2015). Cross-sectional analysis of critical risk factors for PPP water projects in China. *Journal of Infrastructure Systems*, *21*(1). https://doi.org/10.1061/(ASCE)IS.1943-555X.0000214

Chen, C., Lv, L., Wang, Z., & Qiao, R. (2023). Bargaining optimization model for risk renegotiation with fairness concerns in infrastructure PPP projects. *Engineering, Construction, and Architectural Management*, *30*(9), 3876–3894. https://doi.org/10.1108/ECAM-11-2021-1006

Chiang, L. Y., Earl, G., Liu, B., Reid, S., & Roca, E. (2022). Risk analysis in social housing delivery: A public-private partnerships approach. *Australian Journal of Public Administration*. https://doi.org/10.1111/1467-8500.12535

Chou, J. S., & Pramudawardhani, D. (2015). Cross-country comparisons of key drivers, critical success factors, and risk allocation for public-private partnership projects. *International Journal of Project Management*, *33*(5), 1136–1150. https://doi.org/10.1016/j.ijproman.2014.12.003

De Castro E Silva Neto, D., Cruz, C. O., Rodrigues, F., & Silva, P. (2016). Bibliometric analysis of PPP and PFI literature: Overview of 25 years of research. *Journal of Construction Engineering and Management*, *142*(10). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001163

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dorfeshan, Y., Allah Taleizadeh, A., & Toloo, M. (2022). Assessment of risk-sharing ratio with considering budget constraint and disruption risk under a triangular Pythagorean fuzzy environment in public-private partnership projects. *Expert Systems with Applications*, *203*. https://doi.org/10.1016/j.eswa.2022.117245

Fan, W., Song, J., Chen, L., & Shi, J. (2022). Research on risk compensation distribution of sludge treatment private-public–partnership (PPP) project based on ecological perspective. *Journal of Environmental Protection and Ecology*, *23*(6), 2289–2296. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85140105978&partnerID=40&md5=011b97e80560117f3a58211a5f411a13

Fathi, M., & Shrestha, P. P. (2023). Identification of critical success and risk factors for public-private partnership highway projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *15*(1). https://doi.org/10.1061/(ASCE)LA.1943-4170.0000587

Feng, Y., Guo, X., Wei, B., & Chen, B. (2021). A fuzzy analytic hierarchy process for risk evaluation of urban rail transit PPP projects. *Journal of Intelligent and Fuzzy Systems*, *41*(4), 5117–5128. https://doi.org/10.3233/JIFS-189997

Geng, L., Zheng, H., & Sun, Y. (2022). The effect of completion risk and project profitability on the investment decisions of the private sector in PPP projects. *Mathematical Problems in Engineering*, *2022*. https://doi.org/10.1155/2022/3185061

Hartono, B., Ghifari, M. D. A., & Dianita, O. (2021). Risk allocation preferences in Indonesian electricity public-private partnership projects: A conjoint analysis. *IEEE Engineering Management Review*, *49*(3), 154–174. https://doi.org/10.1109/EMR.2021.3087809

Jokar, E., Aminnejad, B., & Lork, A. (2021). Assessing and prioritizing risks in public-private partnership (PPP) projects using the integration of fuzzy multi-criteria decision-making methods. *Operations Research Perspectives*, *8*. https://doi.org/10.1016/j.orp.2021.100190

Jokar, E., Aminnejad, B., & Lork, A. (2023). A risk allocation model among the elements of freeway projects in public-private partnership (PPP) method using integrated fuzzy multi-criteria decision-making techniques. *Australian Journal of Civil Engineering*, *21*(1), 116–140. https://doi.org/10.1080/14488353.2022.2083288

Khahro, S. H., Ali, T. H., Hassan, S., Zainun, N. Y., Javed, Y., & Memon, S. A. (2021). Risk severity matrix for sustainable public-private partnership projects in developing countries. *Sustainability*, *13*(6). https://doi.org/10.3390/su13063292

Kouton, J., Sanogo, W., & Djomgoue, N. (2023). Risk allocation in energy infrastructure PPPs projects in selected African countries: Does institutional quality, PPPs experience, and income level make a difference? *Economic Change and Restructuring*, *56*(1), 537–580. https://doi.org/10.1007/s10644-022-09433-0

Kumar, L., Jindal, A., & Velaga, N. R. (2018). Financial risk assessment and modeling of PPP-based Indian highway infrastructure projects. *Transport Policy*, *62*, 2–11. https://doi.org/10.1016/j.tranpol.2017.03.010

Kumar, S., Pandey, N., Lim, W. M., Chatterjee, A. N., & Pandey, N. (2021). What do we know about transfer pricing? Insights from bibliometric analysis. *Journal of Business Research*, *134*, 275–287. https://doi.org/10.1016/j.jbusres.2021.05.041

Li, Z., & Wang, H. (2023). Exploring risk factors affecting sustainable outcomes of global public-private partnership (PPP) projects: A stakeholder perspective. *Buildings*, *13*(9). https://doi.org/10.3390/buildings13092140

Lima, S., Brochado, A., & Marques, R. C. (2023). Public-private partnerships: A fresh risk-based approach to water sector projects *Infrastructures*, *8*(6), https://doi.org/10.3390/infrastructures8060102

Liu, J., Love, P. E. D., Davis, P. R., Smith, J., & Regan, M. (2015). Conceptual framework for the performance measurement of public-private partnerships. *Journal of Infrastructure Systems*, *21*(1), 04014023. https://doi.org/10.1061/(ASCE)IS.1943-555X.0000210

Liyanage, C., & Villalba-Romero, F. (2021). Disaster risk reduction compliance framework for public-private partnership (PPP) port projects *International Journal of Disaster Resilience in the Built Environment*, *12*(5), 484–499. https://doi.org/10.1108/IJDRBE-05-2020-0053

Mazher, K. M., Chan, A. P. C., Choudhry, R. M., Zahoor, H., Edwards, D. J., Ghaithan, A. M., Mohammed, A., & Aziz, M. (2022). Identifying measures of effective risk management for public-private partnership infrastructure projects in developing countries. *Sustainability*, *14*(21), 14149. https://doi.org/10.3390/su142114149

Moradi Shahdadi, L., Aminnejad, B., Sarvari, H., & Chan, D. W. M. (2023). Determining the critical risk factors of implementing public-private partnership in water and wastewater infrastructure facilities: Perspectives of private and public partners in Iran. *Buildings*, *13*(11). https://doi.org/10.3390/buildings13112735

Nguyen, A., Mollik, A., & Chih, Y. Y. (2018). Managing critical risks affecting the financial viability of public-private partnership projects: A case study of toll road projects in Vietnam. *Journal of Construction Engineering and Management*, *144*(12). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001571

Pai, S., Patnaik, B., Mittal, A., & Anand, N. (2018). Identification of risks causing time and cost overrun in roads and highway projects in India *International Journal of Civil Engineering and Technology*, *9*(3), 683–697. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85044515752&partnerID=40&md5=052916fd86fe7768157d85651fc6af9a

Putri, F. R., Susanti, B., & Toyfur, M. F. (2023). Critical risk analysis of toll road public-private partnership (PPP) project construction phase. *ASEAN Engineering Journal*, *13*(3), 117–126. https://doi.org/10.11113/aej.V13.19462

Ramli, N. H., Adnan, H., & Ismail, W. N. W. (2021). Assessing financial risk in managing public-partnership (PPP) projects. *Malaysian Construction Research Journal*, *35*(3), 11–22. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85129758018&partnerID=40&md5=1cae176a433030dbd96775243d9a3003

Selim, A. M., Yousef, P. H. A., & Hagag, M. R. (2019). Risk allocation for infrastructure projects by PPPs – Under environmental management and risk assessment mechanism. *International Journal of Risk Assessment and Management*, *22*(1), 89–108. https://doi.org/10.1504/ijram.2019.096698

Shams Eldin, R. R. M., Osman, H. M., Georgy, M. E., & Ibrahim, M. E. (2019). Identification and ranking of the risks encountered by wastewater treatment and desalination PPPs in Egypt. *Journal of Engineering and Applied Science*, *66*(2), 243–264. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85064122778&partnerID=40&md5=c4eaf57be5449d6eb8c462e6cf11d425

Sholihin, M., Ali, R., & Wanto, D. (2021). Shariah compliance in Islamic economics: A bibliometric analysis. *Malaysian Journal of Economic Studies*, *58*(2), 315–337. https://doi.org/10.22452/MJES.vol58no2.7

Sidorenko, A., Kilinkarov, V., & Belkov, A. (2021). Risk management in public-private partnerships and other major infrastructure projects. *EDPACS*, *63*(5), 6–19. https://doi.org/10.1080/07366981.2020.1846863

Sumrit, D. (2021). A hybrid fuzzy multi-criteria decision-making model for prioritizing risk mitigation strategies in deep-sea port public-private partnerships. *International Journal of Management and Decision Making*, *20*(4), 412–441. https://doi.org/10.1504/IJMDM.2021.118552

Sun, Y., Liu, M., Hao, S., & Wei, M. (2023). Investment risk assessment of social capital in urban rail transit public-private partnership projects. *Journal of Asian Architecture and Building Engineering*. https://doi.org/10.1080/13467581.2023.2287716

Sunandar, A., & Indiyati, D. (2023). The influence of the planning and preparation stage on the success of public-private partnership local government scheme (KPDBU) availability payment in Indonesia. *Proceedings of the International Conference on Sustainable Collaboration in Business, Technology, Information, and Innovation (SCBTII 2023)* (pp. 93–112). https://doi.org/10.2991/978-94-6463-292-7_7

Tamošaitienė, J., Sarvari, H., Chan, D. W. M., & Cristofaro, M. (2021). Assessing the barriers and risks to private sector participation in infrastructure construction projects in developing countries of Middle East. *Sustainability*, *13*(1), 1–20, Article 153. https://doi.org/10.3390/su13010153

Wang, H., Xiong, W., Wu, G., & Zhu, D. (2018). Public-private partnership in public administration discipline: A literature review. *Public Management Review*, *20*(2), 293–316. https://doi.org/10.1080/14719037.2017.1313445

Xu, Y., Chan, A. P. C., Xia, B., Qian, Q. K., Liu, Y., & Peng, Y. (2015). Critical risk factors affecting the implementation of PPP waste-to-energy projects in China. *Applied Energy*, *158*, 403–411. https://doi.org/10.1016/j.apenergy.2015.08.043

Zapata Quimbayo, C. A., & Mejía Vega, C. A. (2023). Credit risk in infrastructure PPP projects under the real options approach. *Construction Management and Economics*, *41*(4), 293–306. https://doi.org/10.1080/01446193.2022.2151023

Zhai, W., Ding, J., & Ding, L. (2021). Investment risk grade evaluation of new town construction PPP projects: Perspective from the private sector. *Journal of Urban Planning and Development*, *147*(2). https://doi.org/10.1061/(ASCE)UP.1943-5444.0000665

Zhang, J., Wang, T., & Zhang, L. (2021). Legal risk assessment framework for international PPP projects based on metanetwork. *Journal of Construction Engineering and Management*, *147*(8). https://doi.org/10.1061/(ASCE)CO.1943-7862.0002110

Zhang, Y., He, N., Li, Y., Chen, Y., Wang, L., & Ran, Y. (2021). Risk assessment of water environment treatment PPP projects based on a cloud model. *Discrete Dynamics in Nature and Society*, *2021*. https://doi.org/10.1155/2021/7027990

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