

Research Paper

Public-Private Partnership Scheme In Research and Development: A Bibliometric Study

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ABSTRACT

This article investigates the trends of scholarly publication in PPP research of R&D sector during the last three decades, including the publication patterns of the researchers' network and institutional structures. This article applies Bibliometric method by using VOSviewer to analyze and visualize scientific themes obtained from keywords 'PPP and R&D' through articles published in Scopus indexed journals. In mapping these keywords, this study found out that the most discussed topics include drug development, innovation policy, drug discovery, neglected tropical disease, global health, vaccines, and clinical trials. From these keywords, it could be concluded that the majority of the research areas of this topic focuses on the health sector. Lastly, this paper summarizes some future research directions and gives a recommendation. The recommendation is to make a mechanism for how PPP funding can be carried out in R&D activities. The PPP funding is not only meant for research infrastructure development but also R&D activities.

Keywords: public-private partnership, research and development, bibliometric, VOSViewer

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1. Introduction

Public-Private Partnership (PPP) has been widely utilized in various parts of worldwide research emphasizing infrastructure development. PPP opens opportunities for the private sector's involvement to participate in providing public services in the form of infrastructure development (roads, bridges, and hospitals), management, and maintenance. According to Zhang (2005), PPP could provide added value to the output resulting from infrastructure development and sustainability. One of the advantages generated from implementing the PPP financing scheme is the risk-sharing between public and private parties. Rossi & Civitillo (2014) reported that the public and private sectors' participation had certain qualities; when combined, it would ultimately produce good quality. Meanwhile, cooperation and risk-sharing provide the main considerations for the two sectors in combining these qualities.

Of the various sectors developing PPP financing schemes, the research and development (R&D) sector play the central role, to which the government and business entities have currently paid attention. Some examples are evident from the development of R&D infrastructure such as laboratories. For example, the construction of laboratories in Brazil through PPP can augment the economic sector through the autonomy of health technology and technological development in a country (Bonfim et al., 2018).

Along with the exceptionally speedy development of PPP application in various countries, researchers' growing interest during the last two decades to conduct research on the theme of PPP also continues to grow. This improvement has led to significant growth in articles and journals under the PPP theme with various topics, domains, and research methods. The development of academic knowledge of PPP has enabled the researchers to share research findings and explore current conditions and trends about PPP practice (Ke et al., 2009). Similarly, Al-sharif & Kaka (2004) conducted a comprehensive analysis reviewing PPP-related publications in the four selected construction journals from 1998 to 2003. Their review illustrates the coverage of PPP during this period, presenting the gaps that researchers should address in reviewing PPP journal trends and assessing the impact of research on the construction industry.

By considering the crucial role of PPP in relation to R&D, the summary description of research and studies related to these two keywords has provided a literature study along with the related bibliographic approach. A review of literature on PPP and R&D issues through research results and studies have been indexed by Scopus. This systematic literature review is performed to summarize and observe how research and study developments related to PPP and R&D are conducted. According to Helby Petersen (2019), a systematic literature review is described as an appropriate method to provide a concise but comprehensive overview of the developing topic by providing academic evidence. Publications published in Scopus are summarized in this study to enable the readers to navigate the research trends comprising both PPP and R&D issues. It is thus expected that a systematic literature review would address the following questions:

1. When are the keywords in "Public-Private Partnership" and "research and development" used in a Scopus indexed scientific article for the first time?
2. What is the pattern and trend of publication in PPP and R&D research indexed by Scopus?
3. How is the analysis of bibliometric visualization in PPP and R&D studies indexed by Scopus?
4. To link findings on the role of PPP in R&D development with existing concepts and practices in Indonesia, does the PPP issue related to R&D appear in Indonesia in scientific publications indexed by Scopus?
5. To provide a prediction, what are the future research direction?

Literature Review

Bibliometrics is employed to study the interaction between science and technology, produce a mapping of scientific fields, develop new knowledge in a particular field, serve as indicators of future insight to provide a more competitive advantage, and craft the research plans. Bibliometric is a statistical method that can quantitatively analyze research journals on a specific topic through mathematical methods (Chen et al., 2014). Similarly, Reitz (2004) stated that bibliometrics is a mathematical and statistical method to study and identify patterns in the use of literature and library services as material for analysis to determine developments in literature, especially authorship, publication, and use.

According to Glänzel (2003), there are three components of bibliometric, which are: (i) bibliometric for bibliometricians, (ii) bibliometric for scientific disciplines (scientific information), and (iii) bibliometric for science policy and management (science policy). Bibliometrics for bibliometricians becomes the primary bibliometric research domain and has traditionally been employed as a research methodology.

Bibliometric methods have been widely used, especially by information scientists to study the growth and distribution of scientific articles. Researchers may also use bibliometric methods to determine the influence of an author, or to describe the relationship between two or more authors (Tsai, 2011). In addition, bibliometrics can determine the quality of studies, analyze key areas of research, and predict future research directions, such as analyzing trends and forecasts (Tsai, 2015; Tsai & Yang, 2010)

Structured searches were performed on the Scopus database, which is the largest academic database. Analyzing publication trends by utilizing the Scopus online database could help the researchers access the available research journals equipped with built-in analysis tools to produce representative images (Permana & Harsanto, 2020). Further, Scopus's search results could be exported to software for additional analysis, such as through the VOSviewer application, a free computer program for visualizing and exploring bibliometric knowledge maps (Leydesdorff & Rafols, 2012). The advantage of VOSviewer compared to other analytical applications lies in utilizing a text mining function to identify combinations of noun phrases relevant to the mapping and integrated clustering approach and verify data co-citation co-occurrence networks (Eck & Waltman, 2016).

Several previous studies have mapped international publication trends (Ibrahim, 2020) and a systematic literature review related to the PPP theme associated with Infrastructure Development with a locus in Indonesia (Mandasari & Wahyuni, 2019). PPPs have been widely established and are attracting increasing attention. Great efforts have been made to ensure the successful operation of PPP projects. Nikonova (2014), in her journal, stated the main directions of PPP in the field of innovation in Russia, one of which is the innovative orientation of the State order for research and development with public-private financing initiatives. In addition, the OECD STI 2016 describes several types of PPP in research and innovation and examples of programs from several countries. Above all, PPP helps create a collaborative environment to maximize cross-disciplinary expertise among government, academia, and industry. OECD also stated that other benefits could be obtained from the PPP scheme, such as Optimizing the use of resources by sharing costs and risks, and Economies of scale (reaching a critical mass in research) and scope (cross-discipline and cross-sectorial benefits) (OECD, 2016). Therefore, this paper is expected to provide a new scientific visualization method to explore the status and direction of PPP development related to R&D.

2. Methodology

2.1 Data Collection

The data used in this study includes the international publications obtained from Scopus (www.scopus.com). Scopus is acknowledged as the world's largest collection of literature summaries and citations, providing abstracts of peer-reviewed scientific and research literature. Launched in November 2004, Scopus has been a trusted site to access the largest database of abstracts and citations from peer-reviewed literature, indexing journals, and other scientific works, which becomes a standard tool for science policy and research management in recent decades.

This research is considered a bibliometric study by selecting articles in the Scopus database from the initial year of publication to 2020. The use of Scopus as a data reference is because Scopus indexed publications are acknowledged as the global standard in scientific publications and have been widely utilized in the bibliometric analysis. In the data collection process, there was no year delimitation to navigate the issuing year of the keywords utilized by "Public-Private Partnership" and "Research and Development".

2.2 Data Collection Strategy

Search strategies are employed to identify the publications with affirmations as follows: ((TITLE-ABS-KEY ("public private Partnership") AND TITLE-ABS-KEY ("research and development")) AND (EXCLUDE (PUBYEAR, 2021)) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "bk"))). The application of quotation marks (") in obtaining data in Scopus aims to locate the right publication and to discuss the related keywords. To provide a more comprehensive reference,

this study confines the types of article sources, which comprises of "journals", "conference proceedings", "books," and "book series", generating 263 articles.

2.3 Data Analysis and Visualization

This paper utilizes a descriptive research method with a bibliometric approach (Ellegaard & Wallin, 2015; “Meas. Sch. Impact,”2014; Waltman & Noyons, 2018) to examine the scientific literature (Chen, 2017; Xiao & Watson, 2019). This study observes general publication patterns in the number of studies, researchers, academic affiliations, countries, and subject areas. The data analysis is further processed, sequentially arranged, and compiled to present the discussion in the form of tables, infographics, and descriptive interpretation. In addition, this paper employs the bibliometric analysis and visualization produced by VOSviewer version 1.6.15 to visualize and map the analysis by country, keywords, and research topics.

3. Results and Discussion

3.1 Publication Pattern

From the results of data processing performed through Scopus, approximately 263 Documents were obtained related to the keywords "Public-Private Partnership (PPP)" and "research and development (R&D)." Of these 263 documents, the first PPP and R&D keywords appeared in 1986 from Robertson G.E. and Allen D.N.

*“...encourage greater university/industry cooperation and focus regional economic development efforts toward innovation and modernization. To date, the Commonwealth of Pennsylvania has provided \$29 million to the advanced technology centers for joint industry/university **research and development** projects, entrepreneurial development, and education and training.”* (Robertson & Allen, 1986)

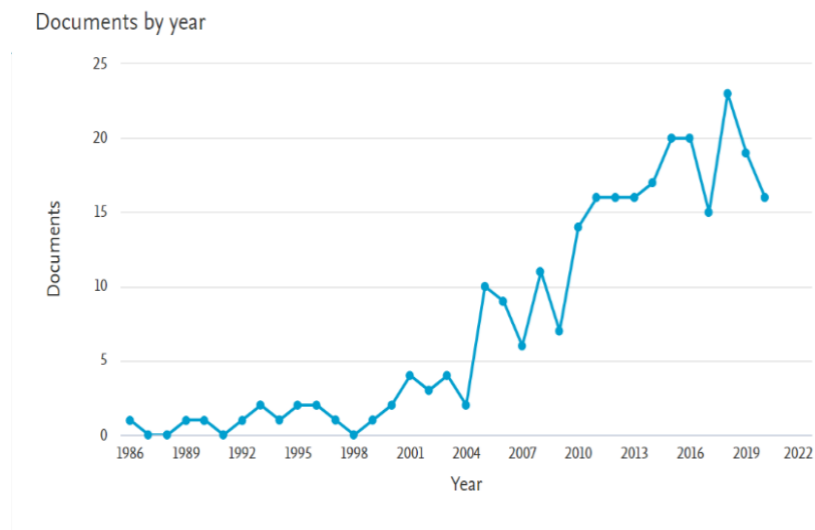


Figure 1. Development Trends in International Scientific Publications with PPP and R&D Keywords

Figure.1 illustrates the Trend of International Scientific Publication. The year 1986 was the first year for the emergence of Scopus indexed scientific publications using PPP and R&D keywords, continuing to increase until 2020. The following Figure.2 illustrates the growing trend of publication in the period of 2010 - 2020.

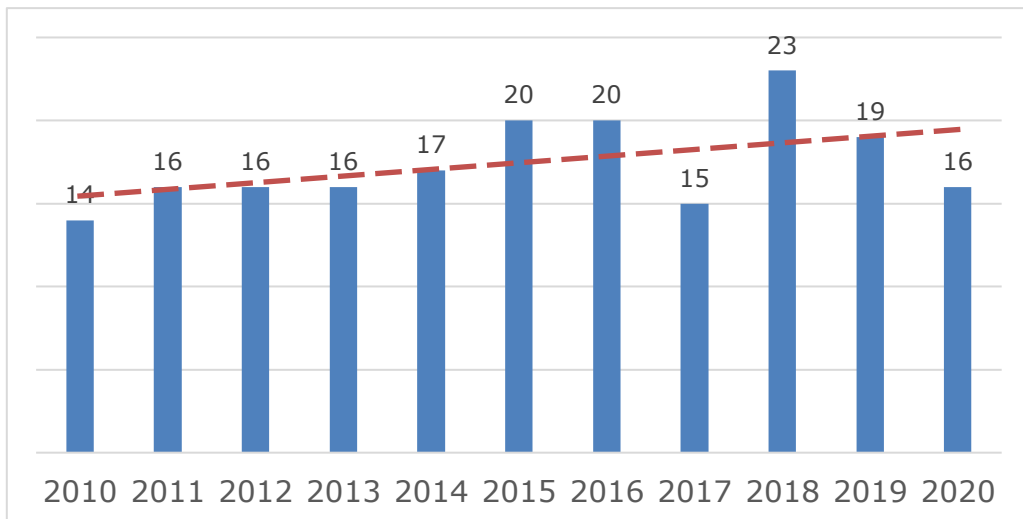


Figure 2. International Publication Trends with PPP and R&D Keywords in 2010 - 2020

The Scopus journal conveys several fields of study, including agriculture, engineering, computer, medicine, and others. Based on the following Figure.3, it is evident that between 1986 and 2020, either researches or publications indexed by Scopus.com related to PPP and R&D were still dominated by research subjects or areas such as Medicine (16.9%), followed by Social Sciences (12.8%), engineering (12.6%), Business Management Accounting (9.09%), and Environmental Sciences (7.1%).

Documents by subject area

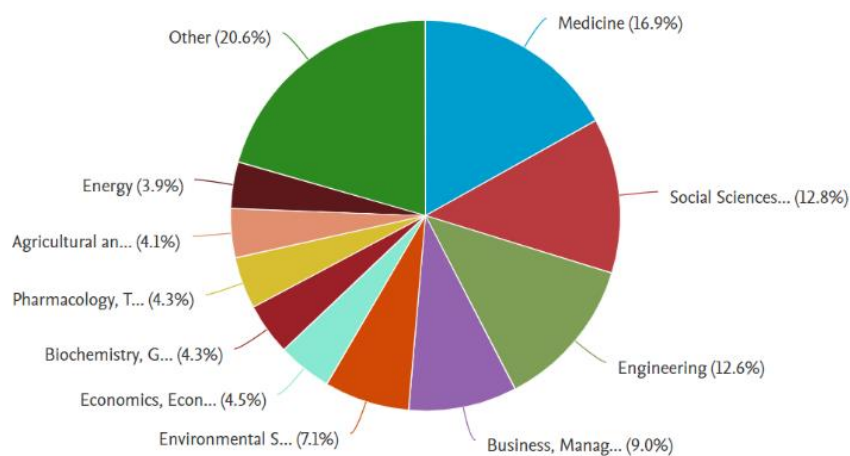


Figure 3. Percentage of Publications based on Research Fields (Subject Areas)

Figure.4 illustrates how Scopus indexed the trend of forms or types of research publications related to PPP and R&D from 1986 to 2020. The scientific articles are the most popular (72.2% equivalent to 190 pieces), followed by Conference Papers of (16.7% equivalent to 44 pieces), Book Chapters of (7.6% equivalent to 20 pieces), and books (merely 3.4% or 9 books).

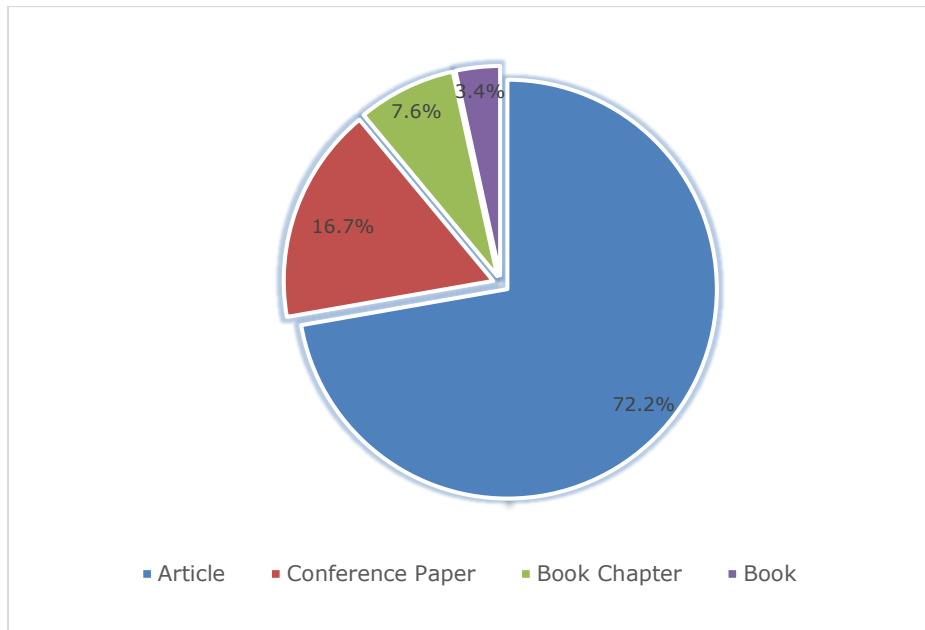


Figure 4. Type of Publication Infographics

Based on Scopus bibliometric metadata, it is revealed that the authors are from 54 countries, and the ten most productive countries are illustrated in Figure.5. The United States becomes the most productive country, publishing 90 articles (34.22%), followed by the United Kingdom with 21 articles (7.9%) and Germany with 18 articles (6.8%).

Documents by country or territory

Compare the document counts for up to 15 countries/territories.

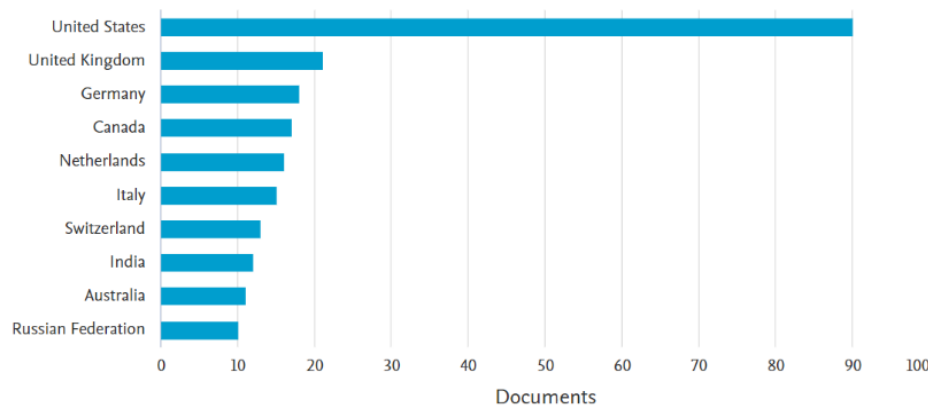


Figure 5. Infographics on Most Productive Countries Publishing PPP and R&D

Furthermore, Figure.6 illustrates that the author of Link, AN, is regarded as the most prolific author in Scopus for the theme of PPP and R&D (affiliated to the University of North Carolina) with five publications, followed by Spielman DJ (affiliated to the International Food Policy Research Institute) with four publications, Crusan J (affiliated with the National Aeronautics and Space Administration) and Scott JT (affiliated with the Department of Economics Dartmouth College) with three publications. In addition, Akinyede J, who is affiliated with the National Space Research and Development Agency with three publications, is ranked the fifth.

Documents by author

Compare the document counts for up to 15 authors.

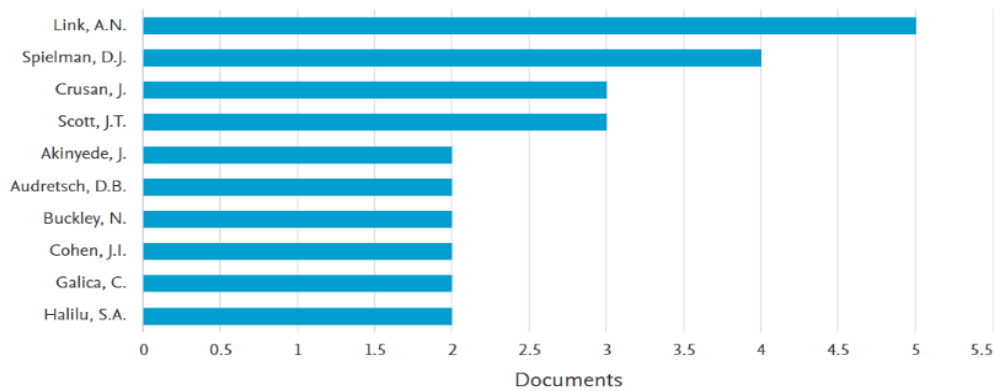


Figure 6. Publication Author Statistics with Scopus Indexed under PPP and R&D Themes

Figure.7 illustrates that the Indian Journals of Public Health Research and Development (Q4) and Science and Public Policy (Q1) become the platform to publish the most research results related to PPP and R&D themes between 1986 and 2020 with six publications. The trend is followed by Globalization and Health (Q1) in the third place with four publications. Dai is ranked fourth and fifth, with the American Journal of Agricultural Economics (Q1) and the Journal of Law Medicine and Ethics (Q2) with three publications.

Documents per year by source

Compare the document counts for up to 10 sources.

Compare sources and view CiteScore, SJR, and SNIP data

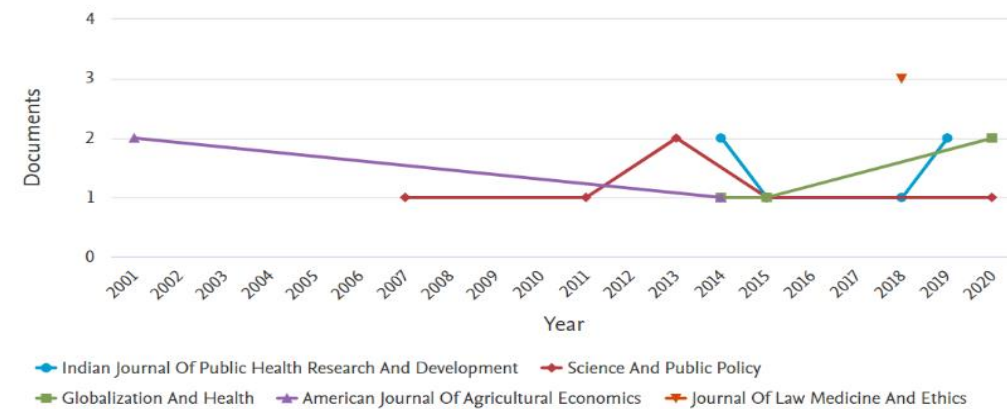


Figure 7. Source of PPP and R&D themes based on Number of Publications

From Figure 1 to Figure 7, it can be analyzed that the trend of PPP studies related to RnD issues is increasing. In general, PPP aims to provide infrastructure, but it is linked to RnD activities in this study. Out of the 263 documents filtered, Indonesia does not have Scopus indexed writings related to the issue of PPP and RnD, even though in implementation, there could be PPP mechanisms in R&D in Indonesia.

3.2 Bibliometric Visualization

Co-Authorship Country Visualization

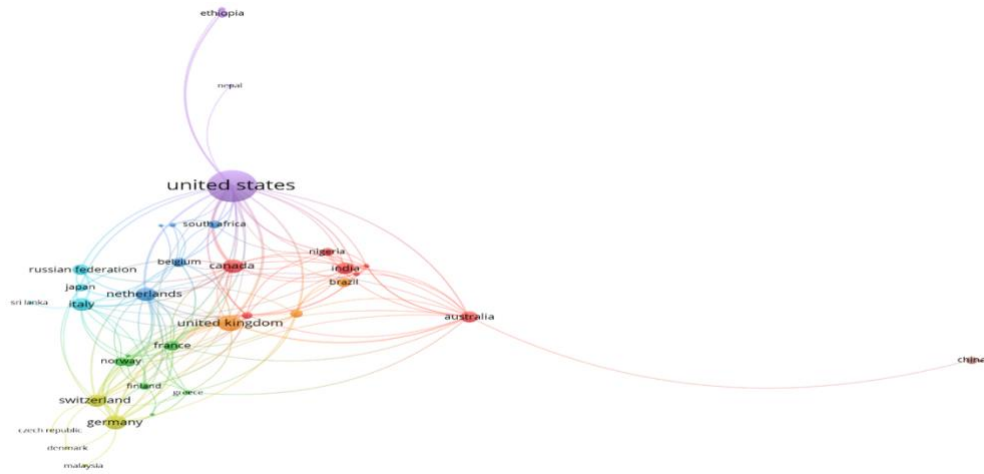


Figure 8. Author Network according to State Affiliation

Figure.8 illustrates a co-authorization network visualization based on countries, depicting a network of authors collaborating with other countries. VOSviewer provides an advantage to display relationships between articles and collaboration between authors. From the proliferated 736 authors across 54 countries, 8 clusters are formed indicated by similar color within the similar cluster. The bigger circle indicates the growing number of authors from a country collaborating with other countries, both within a similar cluster and outside the cluster. The figure also indicates that the United States has the most prominent visualization in terms of circle size compared to the others, signifying that the author from this country has strong links with other countries outside the cluster. Besides the US, other countries with strong links between fellow authors include the United Kingdom, Italy, Netherland, Switzerland, Germany, Canada, and Australia.

Keywords Visualization

This development map produces 699 keywords from the generated 263 articles based on the keywords. The next step is limiting keywords based on the repetition to filter the 70 keywords from 11 clusters. From this keyword information, the theme of each research area was filtered and identified. As illustrated in Figure. 9 and 10, this study presents the two different keyword network visualizations from VOSviewer: network visualization and overlay visualization.

Figure. 9 presents network visualization, where the keywords such as: 'public private partnership' and 'research and development' and 'innovation' have a larger circle compared to other keywords. A bigger frequency of the word occurrence leads to a bigger circle size of the nodes. Keywords with similar color indicate that they are within a similar cluster, narrowly related in terms of the keywords

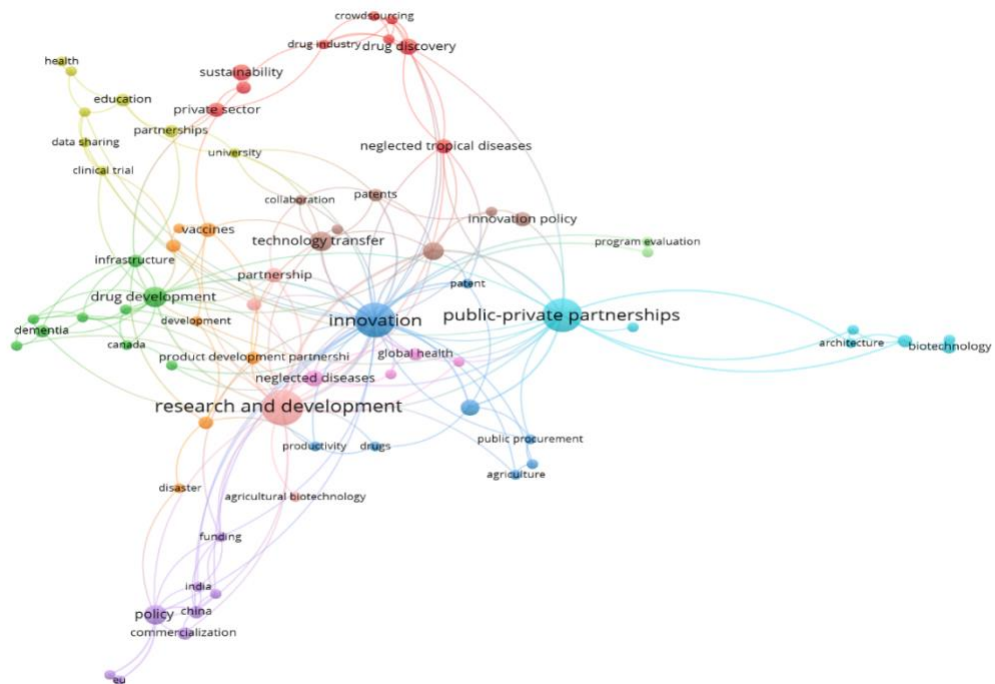


Figure 9. Network Visualization

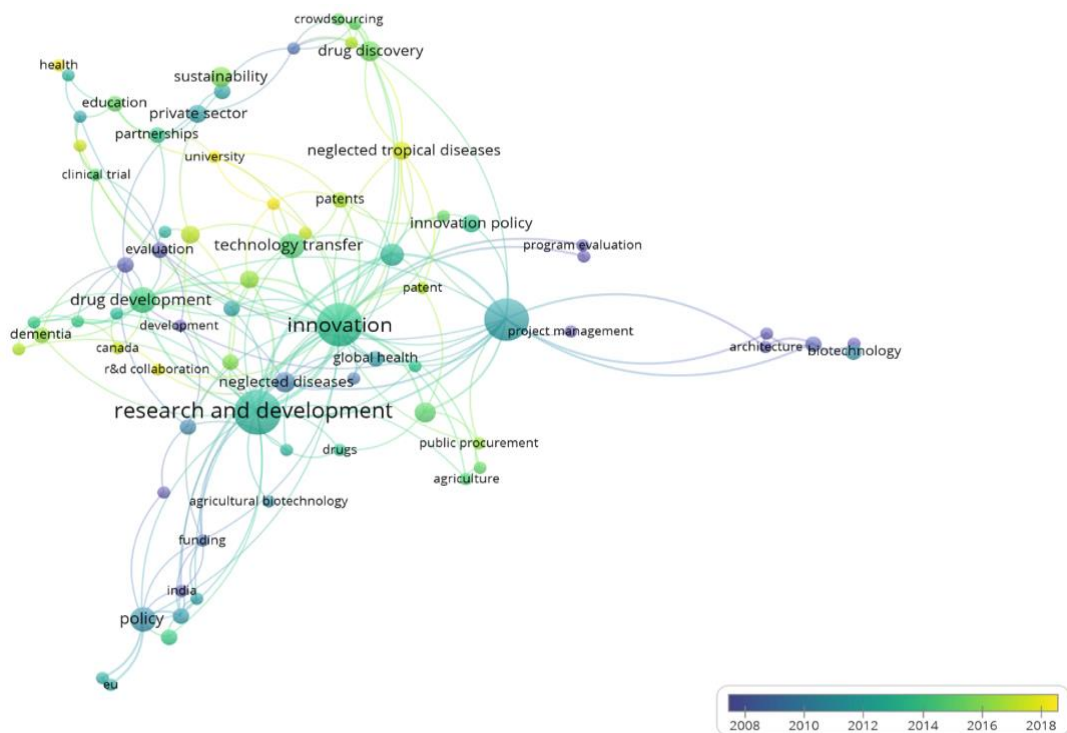


Figure 10. Overlay Visualization

Overlay Analysis provides a visualization of trends from year to year (see **Figure 10**). The keywords that appear under 2010 are infrastructure, development, evaluation. Meanwhile, the keywords that appear in the latest research around 2018 present areas include neglected tropical disease, health, vaccines, and university-industry collaboration.

Table 1. Clusters of co-occurring keywords

Cluster	Keywords
1	cost-benefit analysis, crowdsourcing, drug discovery, drug industry, neglected tropical, disease, open science, pharmaceutical research, private sector, sustainability
2	china, commercialization, disaster, funding, India, policy, research, technology
3	clinical trial, data sharing, education, health, industry, partnership, personalized medicine, university
4	agriculture, drugs, innovation, patent, pharmaceutical industry, productivity, public procurement, public sector
5	Alzheimer's disease, biomarkers, Canada, dementia, drug development, infrastructure, R&D collaboration, treatment
6	agricultural research and development, architecture, biotechnology, design, project management, public-private partnership, risk management
7	collaboration, globalization, innovation policy, intellectual property, partnership, research policy
8	development, evaluation, product development partnership, technology transfer, university-industry collaboration, vaccines, validation
9	developing countries, global health, neglected diseases, pharmaceutical firms
10	agricultural biotechnology, research, and development
11	program evaluation, small business

From the VOS viewer visualization in Figures 9 and 10, it can be summarized that the discussion about PPP in R&D began with the initiation of creating technological innovations through strengthening the resources in research and development through public/private partnerships. Discussions in the following years developed on the discourse of developing public/private partnerships in various sectors such as energy, agriculture, aeronautics and space agencies, infrastructure, transportation, and health. In the past few years, the health sector has indeed been the sector that has received the most attention and has become the subject of discussion on the topic of PPP in R&D. As seen from table 1, the frequency of keywords' occurrence is dominated by health sector topics. This finding is in accordance with the most cited articles written by Trouiller et al. (2002). Their research focuses on public-private partnerships as an effort to fill the gap in fulfilling health needs, especially in developing countries. Further, the study is devoted to developing infectious disease drugs that are 'not profitable' through the formation of collaboration between the private sector and the public sector.

3.3 Future Research Direction

Bibliometrics is effective for giving datasets, which researchers, policymakers, and other stakeholders can use to improve research quality and predict future research (Bayu et al., 2020). Of the 263 documents obtained related to PPP and R&D keywords, this paper selected ten main articles with the most citations to further study the future research agenda (Table 2).

Table 2. Future Research Direction

Article Title	Key Discourse	Future Research Direction/ Explanation
Innovation in the pharmaceutical industry: New estimates of R&D costs (DiMasi et al., 2016)	This article focus on the biopharmaceutical industry that independently finances R&D investment expenditures for the development of new drugs. This drug's development is also sponsored and funded by government and non-profit organizations (public-private partnerships devoted to developing medicines for neglected diseases).	Conducting advanced analysis of the productivity of biopharmaceutical R&D is essential.
Drug development for neglected diseases: A deficient market and a public-health policy failure (Trouillier et al., 2002)	The pharmaceutical industry considers that research and development for neglected diseases are too costly and risky, resulting in low returns. There are public-private initiatives to overcome this limitation through public-private partnerships and incentive packages.	The lack of drug research and development for “non-profitable” infectious diseases will require new strategies. Private-sector research obligations should be explored, and a public-sector not-for-profit research and development capacity should be promoted.
Critical success factors for PPP/PFI projects in the UK construction industry (Li et al., 2005)	PPP/PFI projects have been undertaken successfully in the UK’s public facilities and services. The three most important critical success factors are ‘a substantial and good private consortium’, ‘appropriate risk allocation’, and ‘available financial market.’	How to assess the commitment of both public and private participants to the success of a PPP/PFI project
The anatomy of medical research: US and international comparisons (Moses et al., 2015)	Advances in scientific discovery and service improvement have outpaced current financial capacities and organizational models to support the opportunities.	The United States needs to find new sources to support medical research.
The impact of firm participation in R&D programmes on R&D partnerships (Busom & Fernández-Ribas, 2008)	Public R&D programs trigger a behavioral change in firms’ R&D partnerships, alleviating barriers to cooperation	Suppose public funding increases the development of partnerships. In that case, the output additionality generated by these partnerships has to be verified before concluding that public subsidies are the most efficient tool to reach the goal of increasing innovation. Another mechanism might prove to be more effective or at least complementary to subsidies.
Public-private partnership: From there to here (Croft, 2005)	Public-private partnerships for product development (PD PPP) can be an efficient model for bridging the translational research gap between basic research and clinical development by bringing together expertise from academia, the pharmaceutical industry, and the public sector. The sustainability of funding is a serious problem	Are PDPPPs a new model for producing drugs/treatments? Are PDPPPs achieving a public health impact?
BBMRI-ERIC as a resource for pharmaceutical and life science industries: The development of biobank-based Expert Centres (Van Ommen et al., 2015)	European Biobanking and BioMolecular resources Research Infrastructure-European Research Infrastructure Consortium (BBMRI-ERIC) aims to improve accessibility and interoperability between academic and industrial parties to benefit personalized medicine and disease prevention to promote the development of new diagnostics, devices, and medicines.	In the future, the academic-industry collaboration will have a central role in translating biobank data into actionable solutions. Neither of the parties will be able to do this on its own, as they separately are lacking the necessary combination of resources, expertise, and biological materials, and, perhaps even more important, the broad support of the research subjects
Effective antibacterials: At what cost? The economics of antibacterial resistance and its control (White et al., 2011)	The development and economic model of antibacterial use needs to be rebuilt based on health economic value through dialogue with the various stakeholders, including the pharmaceutical industry, and alternative incentives from ‘push’ to ‘pull’ and funding models, such as public/private partnerships	Society needs a research and development model that succeeds and delivers from start to finish and will ensure that antibacterials are available for future generations throughout their lifetime

Public/private partnerships: innovation strategies and policy alternatives (Link, 2006)	Public/private partnerships affect R&D activities and, thus, innovation. Innovation, in turn, leads to technological advancement, and technological advancement leads to economic growth. Thus, public/private partnerships encompass many policy alternatives that are part of a Nation's innovation strategy	R&D investments are a crucial indicator of advancements in science and technology. At the same time, this relationship between R&D and technological change is as important at the microeconomic level of firm behavior as it is at that macroeconomic level of economic growth.
Repairing the broken market for antibiotic innovation (Outterson et al., 2015)	Public-private partnerships have led to notable progress in drug development for infectious diseases.	Good public health practices curb inappropriate antibiotic use, making a return on investment challenging in payment systems based on sales volume

Note: The table shows the ten top-cited papers - provoking future research direction on the topics

The article above describes the practice of implementing PPP and R&D, where each discussion describes the problems and solutions. From the analysis of the ten most cited papers (from 263 documents), it can be concluded that the tendency of the PPP mechanism for R&D issue is mainly for the health sector, namely the pharmaceutical industry. The pharmaceutical sector expects funding for R&D activities to focus on developing drugs and vaccines, especially for diseases that do not potentially generate profits, such as infectious diseases in poor and developing countries. A financing strategy is needed to overcome the lack of R&D for 'neglected disease' drugs due to the high cost of clinical trials by supporting capital sources with the PPP scheme. Two examples of PPP that stand out in the development of antibiotics are BARDA in the US and ND4BB in the EU (Outterson et al., 2015). It can be concluded that a massive investment in financing is needed to develop biomedical innovations.

Conclusion

From the aforementioned results, it could be concluded that researches and studies conducted under the PPP and R&D themes firstly appeared in 1986. The R&D sector is acknowledged as a promising sector, indicating a growing demand by the government and business entities in developing PPP financing schemes. This conclusion is also evident from the statistical results of 263 articles from 1986 to 2020. That there has been an increasing trend of publication in the last ten years related to PPP in the R&D sector. In terms of affiliated countries, the United States, the United Kingdom, and Germany serve as the home countries that publish the most articles. Meanwhile, the most productive authors are Albert N.Link from the University of North Carolina (USA), David J. Spielman from the International Food Policy Research Institute (USA), and Jason Crusan from Advanced Exploration Systems Division-NASA (USA). Based on the top five ranks in the category of publication sources, there are two journals published by Oxford University publishers, which include: Science and Public policy and the American journal of agriculture economics. Other journals include the Indian Journal of Public health research and Development from RK Sharma Institute of Medico-Legal Publications, Globalization and health journal from publisher BioMed Central Ltd., and Journal of law medicine and ethics from SAGE Publications Inc. Furthermore, the most discussed PPP topics in Research and Development include innovation, research, and development, public-private partnerships, drug development, innovation policy, drug discovery, neglected tropical disease, global health, biotechnology, vaccines, and clinical trials. From the keyword analysis, it is revealed that most of the research areas on this topic focused on the health sector.

To sum up, this paper uses a systematic review through structured search and literature analysis, and the process is transparent and reproducible. This research focuses on the context of PPP and R&D activities (not only related to building research infrastructure). As seen in Scopus metadata, Indonesia does not have any publications or literature about this issue; therefore, it is necessary to encourage publication based on the best practice or ideal PPP implementation planning in Indonesia. This paper also summarizes some future research directions and gives a recommendation. The recommendation is to make a mechanism for how PPP funding can be carried out in R&D activities. The PPP funding is not only meant for infrastructure development but also for R&D activities (including Clinical Trials and Product Feasibility Tests which generally require substantial funding). In addition, a study is needed to see the PPP concept of costs and benefits in R&D in Indonesia.

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