



## Review of studies on the public–private partnerships (PPP) for infrastructure projects

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Received 18 July 2017; received in revised form 23 February 2018; accepted 12 March 2018  
Available online xxx

### Abstract

Public–private partnership (PPP) is an approach adopted to enhance the economic value of infrastructure outputs, and it encompasses a broad spectrum of public sector infrastructure. Many researchers have explored the application of PPP to improve the efficiency of infrastructure delivery. This study aims to review the existing PPP research to explore the status quo, trends, and gaps in research for PPP infrastructure projects. A systematic process involving a three-phase word frequency analysis, cluster analysis, and a search on potential research topics helps to provide enough potential articles related to PPP research and reduce arbitrariness and subjectivity involved in the research topic analysis. As a result, six main research topics aligned with the infrastructure PPP projects were derived. The research gaps and research directions can serve as a motivation for researchers and practitioners to work on the next generation of PPP studies to support the development of infrastructure.  
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*Keywords:* Public–private-partnerships (PPP); Infrastructure; Build-operate-transfer (BOT); Private finance initiative (PFI); Cluster analysis; Word cloud

### 1. Introduction

Public–private partnerships (PPP) are widely used to deliver a series of infrastructure projects in the world. The PPP approach increases the economic value of infrastructure outputs (Zhang, 2005) and facilitates the overall development of infrastructure (Li et al., 2016b), such as the establishment of transportation infrastructure, sports facilities, water conservancy facilities, and waste-to-energy plants. Alongside the rapidly increasing application of PPP, research interest in the topic has also surged during the last two decades, leading to significant growth in the number of published articles as well as in the diversity of research topics, domains, and methods. The development of the academic body of knowledge on PPP has

enabled researchers to share research findings and explore the status quo and trends about the PPP practice; thus, this analysis of articles published in academic journals will assist researchers in exploring the current status and future trends of the chosen topics in this area (Ke et al., 2009).

Ke et al. (2009) analysed 170 studies conducted over the period 1998–2008 selected from the following academic journals: Construction Management and Economics (CME), International Journal of Project Management (IJPM), Engineering, Construction and Architectural Management (ECAM), Journal of Construction Engineering and Management (JCEM), Journal of Management in Engineering (JME), Proceedings of Institution of Civil Engineers—Civil Engineering (PICE-CE), and Public Money and Management (PMM). The results of their study showed that the three traditional topics—risk, procurement, and financing—have been expanded over the years to include the following seven research topic categories: investment environment, procurement, economic viability, financial package, risk management,

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governance issues, and integration research. Marsilio et al. (2011) used bibliometric techniques (citation and co-citation analysis) to analyse articles over the period 1990–2010 from the Social Sciences Citation Index (SSCI) database. Finally, four main clusters were identified—governmental and intergovernmental organizations (IGOs), public administration and public policy academics, scholars studying transaction cost and contract theory, and scholars studying strategy and alliance/network theory. Andon (2012) presented an analysis of relevant PPP literature published up to December 2010 and proposed five research themes that are appropriate for the current PPP research. These themes include the nature of and rationale for PPPs, processes and procedures encouraging the decision-making for undertaking PPPs, processes and procedures for ex-post evaluations of PPPs, merit and worth of PPPs, and PPP regulation and guidance. Neto et al. (2016) used bibliometric methods to study 575 articles related to PPP and its variant, the public finance initiative (PFI), from the Web of Science citation indexing service. Their analysis suggests that PPP research has been focusing on a limited set of topics, which includes contract performance, qualitative costs and benefits, contract design and risk sharing, political and institutional issues, and tests on value for money. Chen et al. (2016) analysed 95 empirical studies examining the influence of PPP data on respective research themes through a meta-analysis. As a result, PPP research topics were classified into the following five categories: performance, contract, risk, value for money, and institutional factors.

Each of these studies has significantly contributed towards summarizing the PPP research history, reviewing the status quo, and outlining trends of research in this area. Concerning the research methods employed, counting or scientometric methods are used by each of these studies to summarize the publication year, journal title, research area, research origin, and geographic scope, among others. Despite their useful contributions, most of these studies rely on subjective judgment in their assessments of status quo and research trends. To reduce the possibility for misinterpretations and misunderstandings among researchers, it is essential to conduct a new objective review of the scientific literature on PPP to derive the current research status and thematic trends. In this study, word frequency and cluster analyses were implemented as a means to classify research topics effectively to reduce the arbitrariness involved in previous studies (Zhou et al., 2016). Compared to other methods, the word frequency analysis can provide greater prominence quantitatively to words that appear more frequently in a source (Riggs and Hu, 2013). Meanwhile, cluster analysis is used to record and categorise specific phenomena in a systematic and quantitative way to reflect the main features of prior literature. In addition, an analysis of research gaps has been afforded limited attention in the extant literature, and yet may act as an important guide for researchers seeking to expand the body of knowledge. Considering the increasing development of PPP in construction and infrastructure, this study aims to provide a more objective overview of existing PPP research and explore potential research gaps and research directions.

## 2. Methodology

Due to a reduction in the arbitrariness involved in such studies, quantitative statistics was employed to determine the number of publications in journals, years, geographical areas, and PPP types. The word frequency and cluster analyses were implemented as the foundations for classifying research topics because of their suitability for research. Subsequently, word frequency analyses were conducted based on word clouds (or tag clouds). Compared to other methods, one of its advantages is that word clouds are graphical representations of word frequency that provide greater prominence to words that appear more frequently in a source (Riggs and Hu, 2013). In addition, cluster analysis, which is used to record and categorise specific phenomena systematically to reflect the main features of prior literature, is used to visualise grouping of sources that share similar words or attribute values.

Thus, the review analysis provided a comprehensive disclosure of PPP applications and ensured that the results of this study are reliable and valid. This study also employed a systematic process to review the existing PPP research literature on infrastructure projects and to explore research gaps and suggestions for future study. Fig. 1 divides the research framework into a two-stage process. A comprehensive literature search and a systematic coding process of articles relevant to the PPP infrastructure projects was conducted in Stage 1, and an analysis of filtered articles was conducted in Stage 2 to analyse research topics, explore research gaps, and research directions. The flow of the overall research framework of the current study comprises the following six steps.

The six research steps are as follows:

Step 1 Determining the academic databases that can be used for article search and selection: To conduct a comprehensive review of previous researches in a research area, a methodical selection of journals in academic databases is necessary (Osei-Kyei and Chan, 2015). Databases used for bibliometric techniques usually come from different sources. One objective way to identify different source documents is to select journals and studies in a broader scope (Marsilio et al., 2011). Before determining the academic databases used for article search and selection, and as an initial screening process, pre-search was carried out to ensure that the selected academic databases are reasonable. The result of pre-search showed the Web of Science to be an appropriate option because it included articles in a broader scope. However, the Web of Science did not provide complete information of several PPP studies in some reputable journals such as CME and ECAM. Therefore, other database and journals should be affiliated with publishers to facilitate a comprehensive article search. As the largest and the most important publisher of civil engineering knowledge, the American Society of Civil Engineers (ASCE) includes several important studies on the construction and infrastructure industry. Additionally, most of the reputable journals

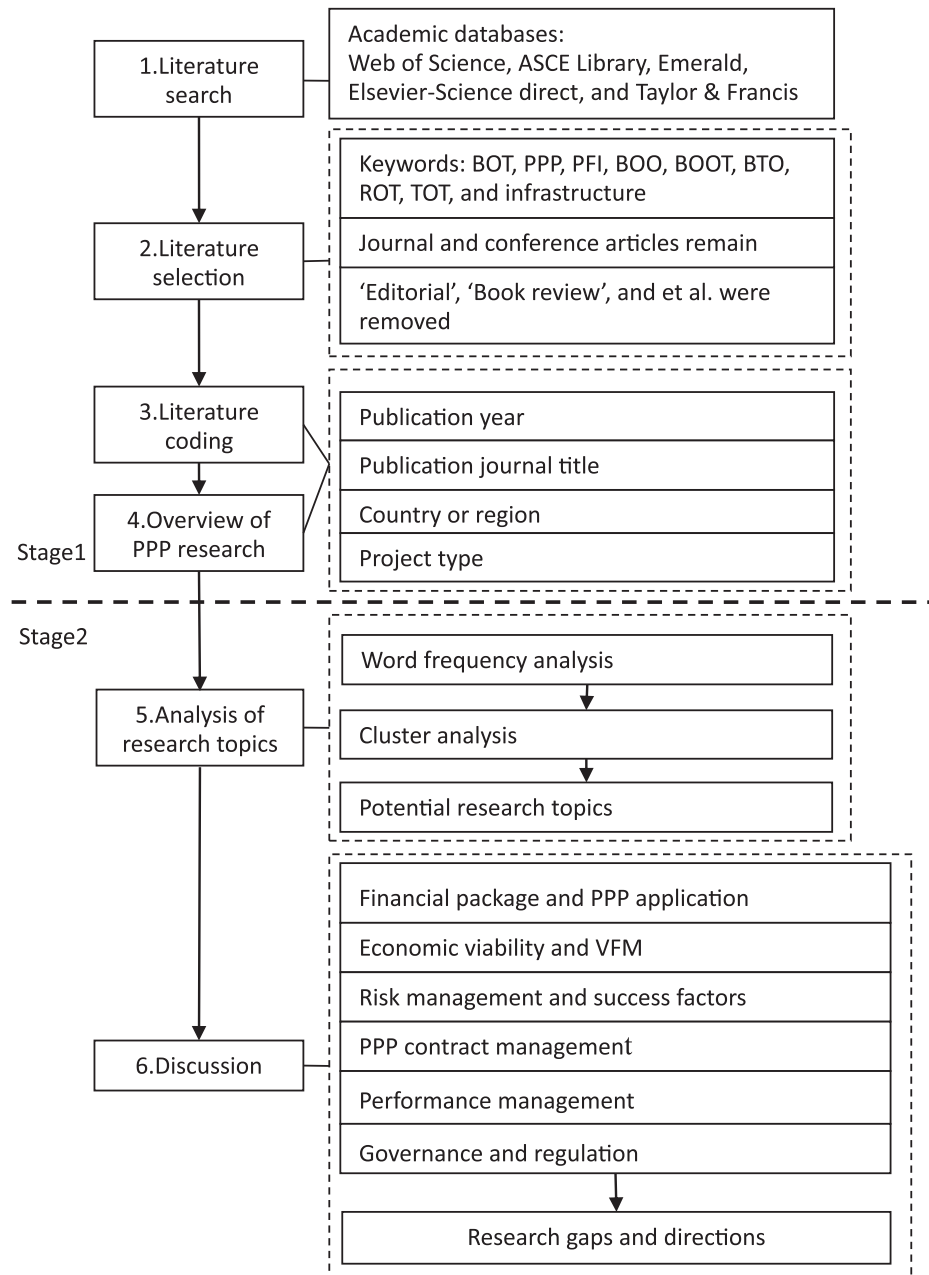


Fig. 1. Flow of overall research framework.

were included in Emerald, Elsevier, and Taylor & Francis, which also have important positions in the construction management and infrastructure industry. Therefore, and referring to the databases scope adopted by Zhou et al. (2016), Emerald, Elsevier, Taylor & Francis, and ASCE were added to the search scope together with the Web of Science. Consequently, five academic databases—the Web of Science, ASCE Library, Emerald, Elsevier-Science Direct, and Taylor & Francis—were selected for the literature search due to their comprehensive coverage, among relevant journals; this selection is different from Osei-Kyei and Chan's (2015) and Ke et al.'s (2009) search scope as it confines to specific journals.

Step 2 Formulating article selection criteria and identifying used articles: The acronym 'PPP', which is widely and frequently used worldwide, was mentioned in the literature in different forms as per Neto et al. (2016); some of the references to PPP include public-private partnerships, PPP, and its variants including the PFI and build-operate-transfer (BOT) procurement methods. Comprehensive search words that were related to PPP were public-private partnership, private finance initiative, build operate transfer, privatised infrastructure, and privately financed, among others. Meanwhile, the search was further limited to the 'infrastructure' subject area. Through pre-search, a limited number of articles were found with the word 'infrastructure' in the title,

abstract, and keywords. In order to broaden the search scope of literature, studies with these specific terms were found to have a relationship with PPP in the title, abstract, or keywords. Additionally, studies with the word ‘infrastructure’ expanding to the full text were considered to meet the requirements of this study. Thus, the following search schema was adopted:

TITLE-ABS-KEY (“public private partnership” OR “public private partnerships” OR “build operate transfer” OR “build-operate-transfer” OR “build/operate/transfer” OR “private finance initiative” OR “transfer operate transfer” OR “build own operate” OR “build own operate transfer” OR “build transfer operate” OR “reconstruct operate transfer” OR “PFI” OR “BOT” OR “PPP” OR “BOO” OR “BOOT” OR “BTO” OR “TOT” OR “ROT”) AND FULL-TEXT (“infrastructure”) AND (LIMIT-TO (LANGUAGE, “English”)).

- Step 3 Determining article coding method and coding filtered articles: The titles, keywords, and abstracts were used to code the articles for further analysis. Concerning articles wherein abstracts do not provide adequate details, the full-texts of the articles were used for coding. The information used in the analysis comprises the following: the title of the study, publication year, journal title, country or region where the studies were conducted, project types, and disciplines. The results of the preliminary search are shown in Table 1. After the removal of repetitive articles, articles published under the broad categories of ‘editorial’, ‘book review’, ‘discussions and closures’, ‘letter to the editor’, and ‘articles in press’ were also excluded from the analysis. The resulting 754 journal and conference articles were screened out. The results of the coding process of these articles are showed in Section 3, titled ‘Overview of PPP Research’.
- Step 4 Producing an overview of PPP studies: An overview of PPP researches was carried out in detail under the following categories: number of publications per year, publication journal title, publications distributed by country or region, publications distributed by project type, and publications distributed by different disciplines.
- Step 5 Identifying the research topics: The word frequency and cluster analyses were implemented as foundations for classifying research topics to reduce the arbitrariness involved in such studies. As a result, six research topics were identified and relationships between different topics were analysed. To decrease the arbitrariness and subjectivity involved in the identification of research

topics, the qualitative research software, NVivo, was utilised to calculate the word frequency and conduct clustering analysis between the words used in the abstracts of the filtered articles in the step 3. Large amounts of unstructured data should be dealt with in the review analysis; this poses several technical and conceptual challenges for researchers. The software NVivo was adopted as a research instrument when performing qualitative research to help researchers address the challenges faced during the review analysis. Although the software CiteSpace also offers benefits when conducting a review of a typical research topic through co-citation and the pathfinder algorithm, occasionally the visual output data in CiteSpace is basic, and hence does not consider useful information (Chen, 2009). In comparison, NVivo not only shows output data comprehensively but also helps to think about the data and manage ideas, thereby exploring relationships in the data and finding emergent concepts, which are more suitable for this study (Brandão and Míguez, 2016). It can be a crucial resource when the researcher, during qualitative research or content analysis, wants to understand coding categories a-priori based on the research question, clustering comments under similarity themes, and writing descriptive explanation summarizing each theme.

- Step 6 Identifying the research gaps and research directions: In this context, a clustering algorithm guided by the Pearson correlation coefficient is used to generate a dendrogram or cluster tree. A research gaps framework is set up based on research topics, research gaps and future directions were identified in this Step.

### 3. Overview of PPP research

#### 3.1. Number of publications per year

Tiong (1990) analysed six projects and showed that the BOT concept, which intrigues common interest among the government, sponsors, lenders, investors, and contractors, is viable even for large infrastructure projects. Subsequently from 1990 to 2000, Tiong and his team played a fundamental role in the development of BOT research. As observed in Table 2, the study titled ‘CSF in competitive tendering and negotiation model for BOT projects’ (Tiong, 1996) is cited most, with the number of citations peaking at 214. As outlined in Table 3, the number of publications concerning PPP witnessed an increase from 2006 onwards. The explosive growth of articles occurred in 2010 and peaked in 2015, with 109 articles. The increase in the number of PPP studies is related to the increased application of PPP in infrastructure in the recent years. However, despite the rapid development of PPP research and its application, the knowledge in this domain is still at a nascent stage due to continued instances of significant cost overruns, schedule delays in several major PPP projects (Love et al., 2015), and several governments seeking to develop models to deliver sustainability outcomes (Villalba-Romero et al., 2015). Therefore,

Table 1  
Literature search results.

Database or journal	Number of publications
ASCE Library	197
Elsevier-Science direct	1633
Emerald	736
Taylor & Francis	928
Web of Science	1417
Total	4911

Table 2  
Tiong's papers in the first decades.

Year	Title	Citations number
1990	Comparative study of BOT projects	89
1992	Critical success factors in winning BOT contracts	147
1995	Competitive advantage of equity in a BOT tender	55
1995	Impact of financial package versus technical solution in a BOT tender	47
1995	Risks and guarantees in BOT tender	120
1996	CSF in competitive tendering and negotiation model for BOT projects	214
1997	Evaluation of proposals for BOT projects	91
1997	Final negotiation in competitive BOT tender	59
1998	Evaluation and competitive tendering of BOT power plant project in china	65
1999	Political risks: Analysis of key contract clauses in China's BOT project	93
2000	Case study of government initiatives for PRC's BOT power plant project	87
2000	Evaluation and management of political risks in China's BOT projects	148

it is necessary for researchers to sustain their efforts in the research of PPP and related topics.

### 3.2. Publication journal title

The diffusion of PPP research studies published in journals and conferences is numerous and scattered. Therefore, Table 4 only illustrated the distribution of the journals that published at least 10 studies on PPP, a total of 375 journal studies. The two journals titles that publish most studies on PPP are the Journal of Construction Engineering and Management (ASCE), with 81 studies published on the subject, and the International Journal of Project Management, with 72 studies published on the subject. Other journals that include studies on PPP are the Journal of Management in Engineering (JME, 39), the Research in Transportation Economics (RTE, 26), Built Environment Project and Asset Management (BEPAM, 25), Procedia-Social and Behavioral Sciences (PSBS, 22), the International Journal of Public Sector Management (IJPSM, 19), and Engineering, Construction and Architectural Management (ECAM, 16). The remaining publications have published less than 15 studies as shown in Table 4.

Table 3  
Number of articles distributed annually.

Year	Number	Year	Number	Year	Number	Year	Number
1990	1	1999	4	2005	19	2011	40
1992	1	2000	3	2006	30	2012	60
1995	5	2001	8	2007	24	2013	83
1996	4	2002	14	2008	28	2014	103
1997	3	2003	8	2009	29	2015	109
1998	1	2004	10	2010	60	2016	107

Table 4  
Number of publications distributed by journal.

Journal title	Number
Journal of Construction Engineering and Management	81
International Journal of Project Management	72
Journal of Management in Engineering	39
Research in Transportation Economics	26
Built Environment Project and Asset Management	25
Procedia - Social and Behavioral Sciences	22
International Journal of Public Sector Management	19
Engineering, Construction and Architectural Management	16
Journal of Financial Management of Property and Construction	15
Construction Management and Economics	13
Journal of Infrastructure Systems	14
Transport Policy	12
Public Money and Management	11
Habitat International	10

### 3.3. Publications distributed by country or region

The 754 reviewed studies originate from 56 different countries and regions covering six continents. All the articles with co-authors originating from different countries and regions were considered in the research origin location as shown in Fig. 2. A total of 165 articles originated in China as the country witnessed a rapid development of the application of PPP in recent years. The UK has produced 108 studies on the subject, as one of the primary destinations that led to the emergence of the PPP concept. Other notable countries or regions with a significant number of studies are the USA (84), Australia (80), and India (40); all these countries contribute more than 30 articles on PPP. Compared to the findings of Ke et al. (2009), we find that the mainland of China, India, Italy, Portugal, and Belgium have made rapid progress in PPP studies in recent years. The rank of India's academic output advanced from the 9th position in 2009 to the 5th position, putting the country ahead of Hong Kong, Taiwan, and Singapore. Portugal and Belgium produce produced 22 and 19 articles, respectively, which exceeded many other countries. These findings coincide with previous studies, indicating that the UK, China (including Hong Kong and Taiwan), Australia, the USA, India, Italy, Singapore, and Germany play leading roles in the field of PPP research.

Recent research also reveals variations in PPP implementation between developed and developing countries. Compared to developed countries, developing countries face more obstacles, such as the shortage of government financial resources, public sector inefficiencies, huge uncertainties in contractual environment, public and private partners' capacity deficiencies, weak political willingness, and administrative bottlenecks (Kwofie et al., 2015; Babatunde et al., 2015). These obstacles have posed challenges in drafting complete contractual agreements to cover all contingencies and achieve value for money in PPP projects (Appuhami and Perera, 2016). However, PPPs are more appropriate for developing countries because such countries can benefit more from the access to new capital and technical expertise brought in by a PPP (Gordon, 2012). The private

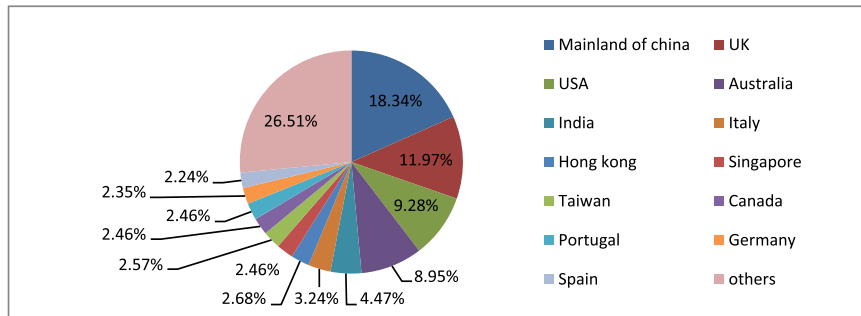


Fig. 2. Research origin of PPP published studies.

sector in developing countries provides a promising platform for PPPs in terms of financial advantages, efficiency advantages, and innovation advantages, compared to the traditional government procurement model (Willoughby, 2013). Based on sophisticated legal frameworks and rich experience, most of the risks in PPP projects disappear or are strongly mitigated after the construction phase in developed countries, while some important risks (for example, political or regulatory risks) still exist during the operation phase in developing countries (Albornoz and Soliño, 2015). There were evident differences in PPP project-types between developed and developing countries, owing to differences in the abilities, environments, and demands. The PPP project activities have been concentrated in varied project-types in developed countries, whereas developing countries have received only minimal infrastructural (water supply and transport, among others) investment through PPPs (Siemiatycki, 2013).

### 3.4. Publications distributed by project type

Of the 754 studies, 379 studies focused on specific infrastructure projects. As shown in Table 5, at the top of the list, 111 studies focussed the application of PPP in transport projects. Among these studies, 64 studies applied the generalised word ‘transport’, 32 studies conducted research on the word

Table 5  
Number of publications distributed by project types.

Project types (words used in studies)	Number of studies (detail)	Ranking
Transport (transport, road, and highway)	111 (64,33,14)	1
Health/hospital (health and hospital)	39 (25,14)	2
Water supply	37	3
Network (network and telecommunications)	24 (13,11)	4
Power plant/energy (power plant, energy, bioenergy, and others)	21 (12,3,2,5)	5
Housing (housing, low-cost housing, real estate, and construction)	20 (6,3,2,9)	6
Urban rail transit (urban transport and urban rail transit)	20 (7,13)	7
Urban development (urban renewal and land development)	16 (11,5)	8
Education/school (education and school)	16 (5,11)	8
Waste management	11	10
Rail (rail and high speed rail)	8 (5,3)	11
Others	56	–
Total	379	–

‘road’, and 14 studies used the word ‘highway’. Concerning the second place on the list, 39 studies were oriented towards the ‘health/hospital’ area, while studies including the keywords health and hospital totalled to 25 and 14, respectively. The results coincide with the previous research by Neto et al. (2016) in which transport and health topped the list of project types. However, contrary to the findings of Neto et al. (2016), projects oriented towards water supply, network, and power plants/energy projects come in the top five of the list, while education occupies the ninth position after urban rail transit and urban development.

As shown in the top five of the list in Table 5, the history of PPP application in transport, water, and energy projects dates back longer than the health and network projects. In other words, economic infrastructure projects, which refer to facilities and services that facilitate the achievement of economic development targets (e.g. roads, tunnels, and bridges), are considered more mature in the PPP experience than social infrastructure projects, which refer to facilities and services that facilitate the achievement of social targets (e.g. hospitals, schools, and network) (Jefferies and McGeorge, 2009). Based on the clear charge mechanism, mature regulatory system, and appropriate return and risk allocation methods in economic infrastructure projects, the scope of PPP application becomes more extensive in transport, water, and energy PPP projects. In the transport projects, the private finance application scope extended from single a toll road to encompass high speed road project, and subsequently the metropolitan transport system (Yuan et al., 2010). Concerning the energy domain, the PPP concept was first implemented for power plant projects, followed by waste-to-energy, bioenergy, and other energy projects. Owing to the complexities of social infrastructure projects, where clients and building users are diversified, PPP becomes the most challenging and interdisciplinary approaches in all procurement methods (Sastoque et al., 2016). To meet the increasing needs of healthcare and signal communication, many governments make use of private finance contracts to deliver healthcare infrastructure and technical infrastructures. Health and network projects occupy the top five positions in the list because of the huge market demand and user-charge mechanism (Leviäkangas et al., 2015; Colla et al., 2015). Concerning PPP application, economic infrastructure got an earlier beginning than social infrastructure; user-charge projects witnessed a rapid development than other projects.

There are three types of PPP infrastructure projects based on payment mechanism, namely, user-charge, government charge, and a viability gap funding. Concerning the development of user-charge infrastructure projects, the utilisation of BOT, TOT, BOOT, and ROT types of mechanisms has triggered many initiatives such as transport, network, and water supply. In this type of infrastructure, ‘operate’ is the key characteristic because of the nature of profitability in user-charge projects. Viability gap subsidies are necessary; however, it is difficult for the user-charge to meet the cost recovery target and reasonable returns of private sector or special purpose vehicles (SPV) such as waste-to-energy and wastewater treatment (Song et al., 2015). Therefore, the utilisations of BOT, TOT, BOOT, and ROT are very popular in viability gap funding projects, with government’s subsidy based on project performance. Proper capital contribution proportion and joint venture model are critical factors that contribute towards the success of these projects; for example, the Beijing No. 4 Metro line project involves private financing of rolling stock, while the public sector finances an infrastructure building project and transfers the ownership of equipment at no additional cost after operating the system for 30 years (Brandão et al., 2012). Projects that do not possess the characteristics of ‘operate’, otherwise referred to as the non-operating PPP projects (e.g. urban road and urban renewal) have explored many possible solutions under government payment mechanisms like BT and governments purchase public service (GPPS) (Morano and Tajani, 2017). To sum up, BOT, TOT, BOOT, and ROT,

among others, which include ‘operate’ type projects, are suitable for user-charge projects and infrastructure projects supported by viability gap subsidies. However, BT and GPPS, which exclude the ‘operate’ type projects, were considered suitable government payment infrastructure projects.

In addition to the project types set out in Table 5, research topics also focus on large-scale infrastructure, critical infrastructure, green infrastructure, and social infrastructure, indicating the increased number of studies that focus on sustainability in PPP and project management.

3.5. Publications distributed by different disciplines

The reviewed studies involved a broader scope of journals across different disciplines. Of the 754 studies, 426 studies focussed on specific disciplines. Among these studies, 234 studies focussed on issues about construction management, 81 studies focussed on public administration, 35 studies were oriented towards urban studies, 28 studies focussed on economics. However, other studies focussed on diverse issues about other disciplines, such as maritime affairs, sociology, and law.

Researchers in different disciplines have taken different theoretical perspectives to explore the PPP phenomena. The main theoretical foundations and special theories for different disciplines are shown in Fig. 3. Based on Andon’s (2012) research agenda principle, the main theoretical foundations were classified into nature and rationale for PPPs, merit and

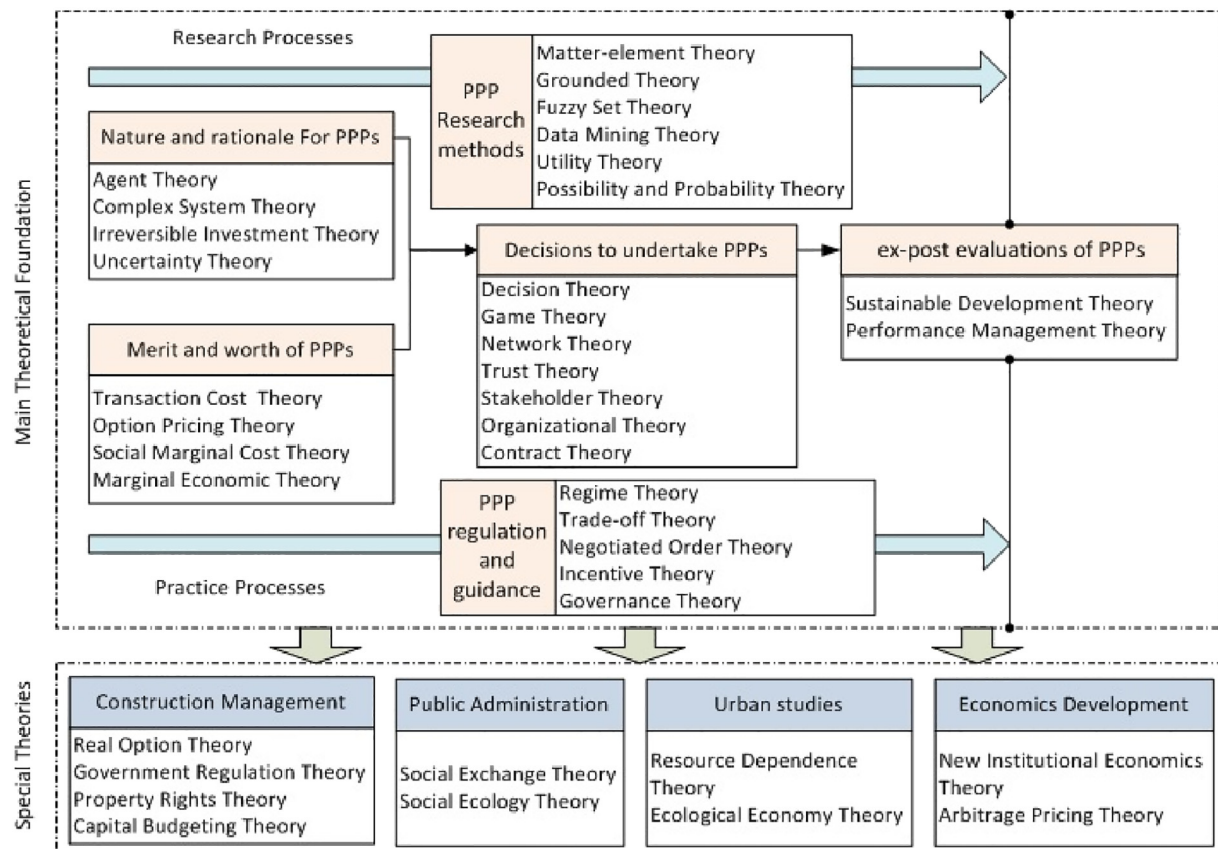


Fig. 3. Theoretical foundations of PPP research in different disciplines.





In the horizontal dendrogram, the cluster analysis demonstrates that similar words were clustered together on the same branch and different items were clustered further apart. Subsequently, a clustering analysis of words that are used in abstracts and keywords is conducted to ensure that the classifications of the research topics are reasonable. A correlation cluster analysis, which selects word correlation based on the clustering, is performed to find statistical relationships between these words. In the current research, the cluster analysis was performed with a selection of grouped items from a more specific internal material, establishing the existence of correlation measurement as the criterion (Zapata-Sepúlveda et al., 2012). Meanwhile, a clustering algorithm guided by the Pearson correlation coefficient is used to generate a dendrogram or cluster tree. Subsequently, the research topics were classified into six categories (see Fig. 5). The function words were not considered; the clustered high frequency words were considered useful for categorizing topic groups. The sources of words, namely, articles including a typical word in the title, abstract, and keywords were used to summarise the research topics in each group as an auxiliary instrument.

In the study by Ke et al. (2009), seven groups, namely, investment environment, procurement, economic viability, financial package, risk management, governance issue, and integration research were explored and summarised. However, the results of the current study clearly indicated that new topics and relationships between topics have been introduced. First, performance management, which includes key performance indicators (KPI) and performance measurement, were studied to drive PPP projects efficiently. Second, Value for Money (VFM) was investigated by many researchers. Third, there exist relationships between different research topics. By considering the results of the word cluster and Ke et al.'s (2009) and Themistocleous and Weame's (2000) categorisation of research topics, six potential research topics were proposed—financial package and PPP application (G1), economics viability and VFM (G2), risk management and success factor (G3), procurement and contract management (G4), performance management (G5), and governance and regulation (G6). The aim was to identify topics in this broad research area, instead of classifying the existing literature. The inclusion of the same article is permitted in different statistical groups, and simultaneously the

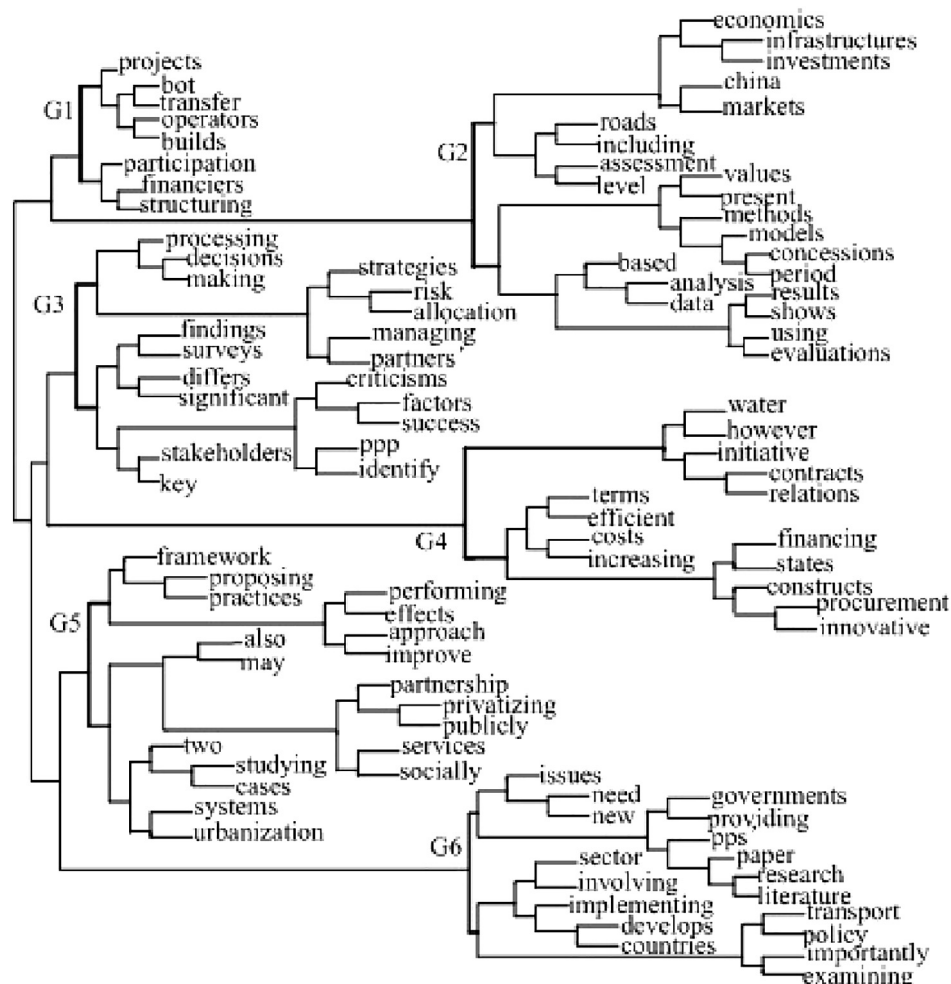


Fig. 5. The horizontal dendrogram of the six groups.

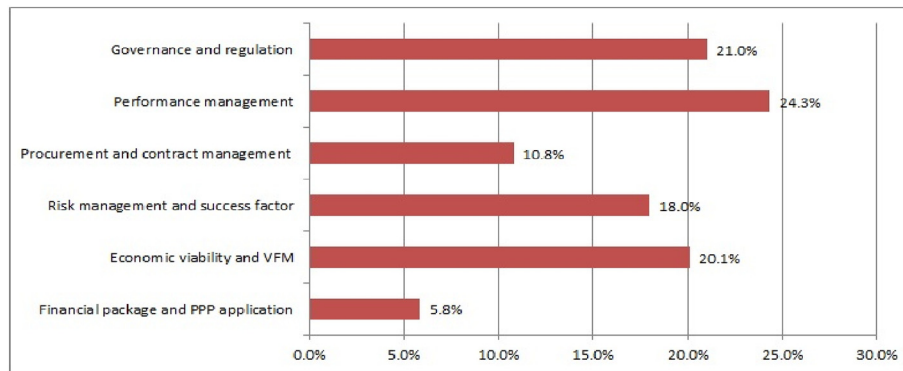


Fig. 6. Material source coverage statistics of each group.

cumulative coverage of every word in each group against the material source is shown in Fig. 6.

## 5. Discussion of research topics

### 5.1. Group 1: financial package and PPP application (G1)

This topic focuses on financial package and uses PPP to deliver infrastructure projects efficiently. Financial package and PPP application are the most fundamental topics in PPP research, although they have a low material source coverage of 5.8%. The research history of these topics clearly shows a notable change of research content from ‘how to operate PPP projects’ to ‘how to popularise the utilization of PPP’.

At the beginning of the 1990s, researchers attempted to establish the features of PPP projects by summarising the processes of actual PPP projects (Tiong, 1990) and by analysing the cost, concession, equity structure (Tiong, 1995a), and contracts, thereby setting the theoretical foundation for the study of PPP application and practice (Tiong, 1992). They analysed the relationship between the investors’ return on equity, projects’ net present value, and debt capacity, and revealed that debt capacity has a direct impact on the projects’ value to investors. At that time, the aim of most of the studies in this area was to clarify the difference between PPP’s procurement and traditional models of procurement and to demonstrate the practical operation of PPP projects.

After 2000, on the one hand, related articles paid more attention to detailed issues in the financial package. Bakatjan et al. (2003) presented a simplified model, which combined a financial model and a linear programming model, to determine the optimum equity level for decision-makers at the evaluation stage of a BOT project. Smith et al. (2004) analysed the negotiation, construction, and operational phases of the Huaibei power plant project in China, and found that the development of PPP markets depends on whether the PPP payment mechanism can be managed properly as an incentive. Iyer and Sagheer (2011) presented a new genetic-algorithm (GA)-based model that yields a set of optimal solutions on capital structure for the key decision variables—grant, debt, and equity. On the other hand, the focus of PPP research shifted towards ‘how

to popularise the utilisation of PPP in more regions and for more types of projects’. Concerning the application of PPP, Shen et al. (1996) studied the widespread use of PPP in developed countries and examined the nature of BOT, potential investment market in China, Chinese government’s policies, and practical procedures of applying the BOT system. Subsequently, they identified the major areas where BOT systems are applied in China (Shen et al., 1996). The application of PPP in developing countries was studied by Malini (1999), who developed a simulation model to examine the financial viability affected by various options such as the toll structure, toll revision schedule, extent of municipal grant, and duration of the concession period. In addition, Malini (1999) undertook research on the application of PPP in bridge construction projects. Subsequently, the research on PPP application extended to urban land development projects (Glumac et al., 2015; Leland and Read, 2013), power plant projects (Smith et al., 2004; Wang and Tiong, 2000), rail projects (Chang and Chen, 2001; Cohen and Kamga, 2013), waste collection and recycling (Ahmed and Ali, 2004; Bhuiyan, 2010), and tunnel projects (Yu et al., 2014; Zhang et al., 2002), among others. Recently, the use of PPP extended to include the procurement of social infrastructure projects, such as airports (Doll and Karagyozev, 2010; Jain, 2015), schools (Amjad and MacLeod, 2014; Kumari, 2016), hospitals (De Marco et al., 2012; Li et al., 2014) and prisons (Jefferies and McGeorge, 2009).

Both in economic and social infrastructure, sustainability is becoming increasingly important in the delivery of infrastructure projects because stakeholders require both ethicality and economic efficiency during a project’s life cycle (Kivilä et al., 2017). As the main goal, among the 17 Sustainable Development Goals (SDGs) of the United Nations (UN), building quality, reliable, sustainable, and resilient infrastructure is crucial to achieving sustainable development in many countries. It is proven that PPPs promote the development of personal competences and support project management for sustainable infrastructure development (Rios et al., 2016). Additionally, PPP is now implemented by the UN as an important tool to achieve the 17 SDGs. The research trends in this topic may enable practitioners to emphasise detailed issues in PPP application, study how to apply the PPP model in other types of infrastructure projects within larger geographical areas effectively and

efficiently, and research on how to operate PPPs to achieve the SDGs of UN.

### 5.2. Group 2: economic viability and VFM (G2)

This topic focuses on how to evaluate the economic viability of PPP and decide whether PPP is suitable for use on specific infrastructure projects. Based on the research conducted by [Hurst and Reeves \(2004\)](#), which adopts the criteria of competition, efficiency/VFM, and re-financing to examine specific PPP projects, this topic includes economic feasibility, VFM, stakeholders' satisfaction, and the economic environment.

Research about PPP's economic feasibility assessment has been undertaken by [Wamuziri and Clearie \(2005\)](#) who provide critical techniques and tools for cost-benefit analysis through their assessment of the economic feasibility of the second Forth Road Bridge in Scotland. [Lee \(2011\)](#) designed an options-based economic analysis with the simulation of multiple scenarios, namely, 'adaptive investment strategies' (i.e. 'start robust, then adapt'), based on the performance of inter-agency and public-private collaboration in earlier stages. Over the past few years, the focus of studies about a PPP's economic feasibility has shifted from the calculation of evaluation indices of traditional methods of economic feasibility assessment to the improvement of evaluation methods as well as the establishment of brand new evaluation systems.

A similar approach is observed concerning the topic of decision-making-based economic feasibility. [Fantozzi et al. \(2014\)](#) examined the practice of developing public sector comparator (PSC) models and analysed the PPP VFM when it was applied to the assessment of the economic feasibility of bioenergy projects. VFM is often regarded as the monetary value of the capital through PPP adoption instead of a more traditional procurement option. Assuming all factors are equal (i.e. quality and outcomes), VFM is demonstrated when the total present value cost (PPP value) of private sector supply is less than the net present value of the base cost of the service (PSC value), adjusted for the cost of risks to be retained by the government, cost adjustments for transferable risk and competitive neutrality effects ([Grimsey and Lewis, 2005](#)). Studies about VFM remain prevalent throughout the extant literature and continue to be a key area of focus for researchers. [Heald \(2003\)](#) analysed VFM from a theoretical perspective of [Pitt et al. \(2006\)](#) and explored the principle factors increasing VFM; the principle factors included optimal allocation and valuation of risk, output-based specification, competition, contract duration and scope, bid costs, innovation, borrowing costs, private sector management skills, client management skills, performance measurement and incentives, and contract flexibility. Among these factors, the valuation of risk, borrowing costs, and bid costs were established as the key parameters of the PSC value. The above-mentioned research focussed on the effect of VFM on decision-making and how to count VFM in practice. However, VFM analysis has failed to reflect the long-term social impact of infrastructure development. To achieve sustainability goals, social parameters must be considered for extending VFM assessment ([Agarchand and Laishram, 2017](#)). Extending the

VFM assessment of PPP might significantly enhance the VFM conceptualization by more comprehensive, and accurate assessment of economic and social value that PPPs create ([Mouraviev and Kakabadse, 2014b](#)). Social value, which refers to the benefit that a society gains as a whole from a PPP infrastructure project, is considered a key sustainability indicator and includes equality, public meeting, and human rights ([Hueskes et al., 2017](#)). With the widespread application of VFM assessment and a lack of attention towards social value in VFM analysis, the focus of academic research concerning VFM is adjusted to explore how to improve ([Visconti et al., 2014](#)), enhance ([Berawi et al., 2014](#)), and maximise VFM ([Martins et al., 2014](#)); what factors drive ([Ismail, 2013](#); [Nisar, 2007](#)) and influence VFM in general ([Hu et al., 2014](#)); and how to appraise social value in VFM assessment ([Boardman and Hellowell, 2016](#)).

The key to an effective PPP lies in the partnership between the public and private sectors as well as in the relationship among other project stakeholders. As a pioneer, [Sohail et al. \(2004\)](#) used both quantitative and qualitative approaches to extract the perspectives of users, operators, and regulators of transport projects. [Henjeweile et al. \(2013\)](#) analysed the process of stakeholder consultation and management; this process involved placing the public at the centre of planning, construction, and operation of PPP projects that aim to achieve mutual benefits. [De Schepper et al. \(2014\)](#) analysed the management responsibilities among critical stakeholders and found that meaningful division of responsibilities will affect the requirements of stakeholders in an active or passive way. To achieve stakeholder satisfaction from a financial perspective, the most important expectations of relevant stakeholders were identified across five different stages in the projects by [Kurniawan et al. \(2014\)](#). These stages included the assessment of a project's ability to carry senior debt, sensitivity analysis for key commercial issues, debt service evaluation towards cost overrun and other adverse events, and assurance of a secure operational cash flow. On the one hand, the degree of stakeholder satisfaction influences the suitability of a project for PPP; on the other hand, stakeholder collaboration and performance influence the application conditions of PPP. [Mladenovic et al. \(2013\)](#) introduced an approach to assess the success or failure of PPP projects from the standpoint of each stakeholder and fulfil the different objectives of specific stakeholder groups through a weighted combination.

Economic feasibility, value for money, and stakeholder satisfaction are internal factors that contribute towards assessing the appropriateness of PPP projects, while the economic environment is an important external condition. Therefore, several studies focus on how PPP projects respond to the economic environment ([Daito et al., 2013](#); [Galilea and Medda, 2010](#)) and economic development ([Fitch et al., 2015](#); [Zangouinezhad and Azar, 2014](#)). In summary, the assessment of the appropriateness and the optimisation of PPP application conditions are important elements of the decision-making process for PPP projects.

### 5.3. Group 3: risk management and success factors (G3)

As showed in [Fig. 5](#), clustered result of words in Group 3 illustrated a close correlation between risk management and

success factor. Therefore, this topic colligates PPP risk management and success factors and focuses on exploring methods for risk identification, risk evaluation, and risk allocation; it also explores methods for identifying success factors.

Throughout the literature it is clear that successful PPP projects exhibited unique strategies and capabilities in risk management (Tiong, 1995b); however, risk evaluation is so complex that it requires an analysis of risk from different perspectives of public and private entities (Grimsey and Lewis, 2002). Shen and Wu (2005) explore the way in which various risks existing in the BOT project implementation process have an impact on project cash flow, including revenue and cost. The first step to estimate the influence of risk involves the identification of risk that is specific to each project. The key risks common to many PPP projects that impact revenue are traffic revenue risk, operation risk, demand risk, and debt servicing risk (Singh and Kalidindi, 2006), while those impacting cost include financing, construction, and operation cost overruns (Ibrahim et al., 2006). The perceived magnitude of each risk and the interrelationships of risks in PPP projects enable decision-makers to take appropriate steps in prioritising and analysing project process (Iyer and Sagheer, 2010). Based on identifying and allocating the main risks embedded in the project during the initial stages of the project (planning and design), the decision-makers easily find a cost-effective way to control risk and maximise investment value optimally (Pellegrino et al., 2013). Strategies adopted by project managers usually depend on the predictability of risk impact and controllability of the risk outcome (Trangkanont and Charoenngam, 2014). The decision-making process becomes more systematic and practical when the risk management capabilities of project managers are correctly evaluated (Ameyaw and Chan, 2015). Concerning the methods of risk evaluation, the most widely used technique is the application of a risk register matrix, which includes the specific impact and probability of occurrence of each identified risk. This may be considered alongside a two-dimensional value curve including performance versus worth (Tarek et al., 2002). Another more recent technique is a fuzzy synthetic evaluation approach, which is becoming increasingly popular as a means of assessing the risk level (Ameyaw and Chan, 2013; Xu et al., 2010). Moreover, the Monte Carlo method is used as an effective tool for simulating indeterminacy during the construction and concession periods (Alonso-Conde et al., 2007; Chang and Ko, 2016; Wibowo and Alfen, 2013).

As one of the main benefits of the PPP models, the allocation of risk between public and private sectors has attracted significant interest from researchers. The fundamental concept of proper risk allocation to enable both public and private sectors to adopt the most appropriate strategy of risk allocation was confirmed by Abednego and Ogunlana (2006). Risk allocation strategies were further studied, particularly, in terms of governance structure (Jin and Zhang, 2011; Jin and Doloi, 2008). Due to differences in PPP collaboration and policy background, the way in which risk allocation is carried out varies by regions; this is resulting in a series of risk allocation models for different regions (Chung et al., 2010; Ameyaw and Chan, 2013; Sastouque et al., 2016; Xu et al., 2010). Concerning the vital function of risk allocation, the

optimal allocation of risk is considered as one of the principle factors in evaluating and creating VFM. Properly assessing risks to determine whether the public agency can transfer to the private sector is the most critical step in the VFM evaluation (Ameyaw et al., 2015). Concerning the research method, empirical research on risk allocation employs techniques such as literature analysis, survey tools, results analysis, modelling, and case studies to explore the topic across the range of project types.

In the past decade, a new approach named ‘real options’ became gradually popular in this field. Alonso-Conde et al. (2007) showed through case studies how PPP-imposed conditions can be treated as real options, how these options affect the incentive to invest, and how the public sector can transfer considerable value to the private sector through government guarantees. Park et al. (2013) presented a real option-based contract model to guarantee appropriate risk-sharing between private entities and governments. Pellegrino et al. (2013) developed an option-based risk management framework that can be related to risk mitigation strategies. Therefore, the real options method is considered more flexible than the prevalent approaches and it represents an important step towards improving understanding of risk mitigation in PPP projects.

It is clear from the analysis of previous research that risk evaluation and risk allocation, as critical issues for PPP projects, will continue to be key research topics in the future. To improve the efficiency of risk management, researchers plan to evaluate risk in a more accurate way and explore new approaches of risk-sharing among stakeholders of PPP projects. Owing to the fact that poor risk management practices reduce the chance of success within PPP projects, Tiong (1992) identifies the importance of the calculated risk-taker as the critical success factor of PPP projects. Subsequently, the topic of critical success factors (CSFs) has become popular among PPP researchers. Osei-Kyei and Chan (2015) summarised the findings of the PPP CSFs studies from 1990 to 2013 as well as the CSFs of the reviewed PPP projects. The CSFs that have become widely accepted by scholars include appropriate risk allocation and sharing, strong private consortia, political support, public/community support, transparent procurement, favourable legal frameworks, stable macroeconomic conditions, competitive procurement, strong commitment by both parties, clarity of roles and responsibilities among parties, financial capabilities of the private sector, technological innovation, open and constant communication, detailed project planning, and guarantees provided by the government. For the classification of CSFs, Jefferies (2006) identified CSFs from different groups such as project company, main contractors, investors, operators, and host government. Aerts et al. (2014) divided the CSFs into the following categories: economic, financial, legal, political, procedural, social, structural, and technical factors. Liu et al. (2015) identified CSFs by the phases (initiation and planning, procurement, and partnership) of PPP infrastructure projects. Chou and Pramudawardhani (2015) set up the following five groups of CSFs: stable macroeconomic environment, shared responsibility between public and private sectors, transparent and efficient procurement process, stable political and social environment, and judicious government control. Common with

studies on risk allocation, empirical research and associated research methods are widely used in identifying CSFs.

#### 5.4. Group 4: procurement and contract management (G4)

This topic focuses on procurement tendering, key contract clauses, and contract negotiation within the PPP framework. As showed in Table 2, half of Tiong's studies are about procurement tendering issues, which paved the foundation for the follow-up research and practice of PPP. Additionally, among these 754 reviewed studies, all researches about tendering before 2000 were accomplished by Tiong's team. Tiong's research topic about tendering focussed on technical solution in procurement tendering such as competition, negotiation, risks, and guarantees. In the recent years, the focus on research topics about tendering has shifted to completion efficiency of procurement tendering. Owing to this, PPPs are often characterised by lengthy tendering periods compared to traditional procurement models. Reeves and Flannery (2015) explored the complex array of factors that can impact tendering periods; the study also aimed to explore means to reduce the tendering period and deliver infrastructure on time and within budget. The study also revealed the following factors impacting the tendering period: significant sectoral variations within projects, capital values, overlap with the timing of general elections, and the competitive dialogue procurement method (Reeves et al., 2017). Considering that the success of PPP projects largely depends on the performance of tendering processes, critical factors affecting the effectiveness and efficiency of PPP tendering were conducted (Liu et al., 2016b).

Risk and reward are the key contract clauses that are subject to repetitive negotiation in PPP projects. The concession period is often considered a critical influencing factor for risk and reward and can be determined by the development of quantitative models and well-structured concessionaire selection frameworks (Zhang et al., 2002) to protect the interests of both the government and private investors. Auriol and Picard (2013) suggest that asymmetries in the concession period can be impacted by the shadow costs of public funds and information. Therefore, a better understanding of what is important to each party during negotiations forms an important step in improving the PPP process (Ahadzi and Bowles, 2004). To improve negotiation efficiency, the game theory has been used to introduce the new negotiation method in the BOT bargaining concession models (Shen et al., 2007) and to evaluate the efficiency of changing strategies of negotiation when the project output is standardised (Javed et al., 2014). In addition, Liou and Huang (2008) proposed an automated approach towards the negotiation of BOT contracts using the Monte Carlo simulation model in which high- and low-risk scenarios were obtained to determine whether the contractual negotiation models vary in accordance with the risk levels.

Indeterminacy during long project concession periods and the incompleteness of many PPP contracts highlights the need for an incomplete contract and contract renegotiation. In practice, incomplete contracts, which are most likely to be renegotiated, are popularly used in complex PPP projects, especially under the immature PPP market and corrupt institutional environments (Iossa and Martimort, 2016). Concerning the requirement of

managerial flexibility, Cruz and Marques (2013) propose a double entry matrix as a new model for contract flexibility. Likewise, Nikolaidis et al. (2013) used a road concession case under renegotiation to develop a concession renegotiation framework that combines the estimation of stakeholder payoffs with various available strategic options. Compensation models for the three common compensation measures, namely, toll adjustment, contract extension, and annual subsidy or unitary payment adjustment, were examined by Xiong and Zhang (2014). Concerning why and how PPP contracts are renegotiated, two case studies were examined by Sarmiento and Renneboog (2016). Incomplete contracts and flexible contracts are usually designed under the assumption that there exist considerable transaction costs of specifying more flexible contracts with certain performance obligations in an uncertain environment. Compared to incomplete contracts, complete contracts allow for lower transaction costs in the initial stage but incur higher costs of establishing the terms of ex-post trade (Domingues and Zlatkovic, 2015). The key contract clauses, contract negotiation, incomplete contract, and renegotiation aim to improve the validity of a contract. Based on the trajectory of previous studies, we predict that approaches towards contract renegotiation and methods to improve the effect of a contract will continue to develop into a key research interest area under this topic in the future.

#### 5.5. Group 5: performance management (G5)

As shown in Fig. 6, the coverage of material sources for this topic ranks the highest, hitting 24.3%. However, articles having the word 'performance' in titles amount to 22, which only accounts for 2.9% of the total 754 studies. This finding suggests that while performance is the primary objective of PPP projects, the topic tends to focus on KPI and performance measurement.

Studies that focus on performance have begun to appear over the last decade. Indridason and Wang (2008) analysed the driving factors for job performance in PPP projects and found that employee commitment proved to be an effective predictor of citizenship behaviour and job performance. Yuan et al. (2009) selected 15 performance objectives based on the goal-setting theory and established a conceptual KPI framework; this framework has been developed into a more detailed KPI conceptual model composed of 41 indicators (Yuan et al., 2012). Mladenovic et al. (2013) conducted similar research with Yuan et al. (2009) and introduced a two-layer approach for the performance assessment of PPP projects. The performance of PPP projects is usually evaluated on the basis of the time and cost that is saved through the PPP model. Sometimes, it is related not only to the project 'input' and 'output' but also to the 'process' and 'outcomes' (Liu et al., 2014a).

Since conventional ex-post evaluation is not robust enough to measure the performance of PPP projects, the lifecycle (process-based) evaluation under the performance measurement system has become a promising approach for comprehensive and effective measurement of the PPP performance. The building information model (BIM) was adopted using information technology to evaluate the performance of lifecycle

stakeholders in the future; this is because the model provides digital representation of the physical and functional characteristics of an asset and enables key decision-makers to make informed decisions across a project's lifecycle (Love et al., 2015). Such an approach may also assist PPP projects in meeting sustainability criteria, which are increasingly being considered as CSFs and are facilitating the achievement of project KPIs (Osei-Kyei and Chan, 2016). Researchers also study different features of performance measurement for special regions and types of projects (Tawalare and Balu, 2016). Comparative research on performance measurement between different approaches (Villalba-Romero and Liyanage, 2016) and different project types (Henjewe et al., 2014) occupy a place in this topic; we also predict that these research areas will gain popularity in the future. In addition to the theoretical research, the practice of performance measurement in PPP project has been studied, which shows that a process-based lifecycle performance measurement together with VFM can improve traditional ex-ante and ex-post evaluations.

### 5.6. Group 6: governance and regulation (G6)

This topic focuses on the project governance and government policy environment concerns for PPP projects. In some projects, a mismatch is revealed between the complicated governance approach and the relatively straightforward infrastructures that were developed; this has led to the argument that a better sense of contingency is required in future PPP programs (Hurk and Verhoest, 2014). With a focus on good governance, Dunn-Cavelty and Suter (2009) set up an expanded governance model for the critical infrastructure protection (CIP) and found that policies should increasingly rely on self-regulating and self-organising networks. Devapriya (2006) analysed the theoretical framework for funding in PPP organisations and found that debt has not been effective in controlling managers' behaviour. This is because subordinate financing also serves to address debt agency in the capital structure of those regulated PPP organisations. Evidence reveals that good governance institutions and, specifically, good regulatory quality enhance PPP performance, apparent from the positive effect of good governance institutions and good regulatory quality on investment growth (Sabry, 2015). Proper risk allocation and the strategic approach have enhanced the performance of PPP projects, which is related to the development of good project governance (Abednego and Ogunlana, 2006).

A series of effective methods and approaches were developed to improve individual project governance efficiency; however, the constantly changing economy and frequent policy reformation continuously alter the external environment of governance mechanism. Therefore, researchers are studying key issues in this area to maintain a clear understanding of project governance. In addition to the fact that weak governance has a damaging effect on a country's politics, economy, and public administration, project governance often suffers from a lack of human, physical, and financial resources; poor interdepartmental coordination; fraught relationships between central and local governments; and political interference in day-to-day operations (Bhuiyan, 2010). The issues about project governance were also identified across two dominant interfaces, one between the public and private sectors and the other between the project and societal stakeholders, which Delhi et al. (2012) suggest is typical for infrastructure projects in India. The lack of legal definition of a PPP acts as a barrier to effective PPP management during the development of effective PPP legal frameworks. Controversy over a government's guarantee of legal status, bureaucratic tariff setting for partnership services, non-existent opportunity for private asset ownership, and excessive government regulation of PPP workers' wage rates were all identified by Mouraviev and Kakabadse (2015).

Besides, since some infrastructures are considered public goods, public governance mechanism and the method of implementing a PPP infrastructure project should be given more attention in the future (Zaato and Hudon, 2015). To solve the public governance problems experienced by many PPP projects, the development of government policies and government regulations (Rouhani et al., 2015) was suggested as supportive mechanisms that can improve governance performance.

### 5.7. Relationship between different groups

These six research groups were further categorized based on the theoretical foundations framework. Group 1 focussed on the nature and rationale for establishing PPPs and on the merit and worth of PPPs. Group 2, Group 3, and Group 4 focussed on decisions to undertake PPPs based on proper application conditions, effective risk management, and flexible contract management; however, Group 5 was related to ex-post evaluations of PPPs that aim to improve performance of PPP projects. Group 6 highlighted the importance of improving governance and policies of PPP projects. Based on the lifecycle of PPP implementation in infrastructure projects, the relationships

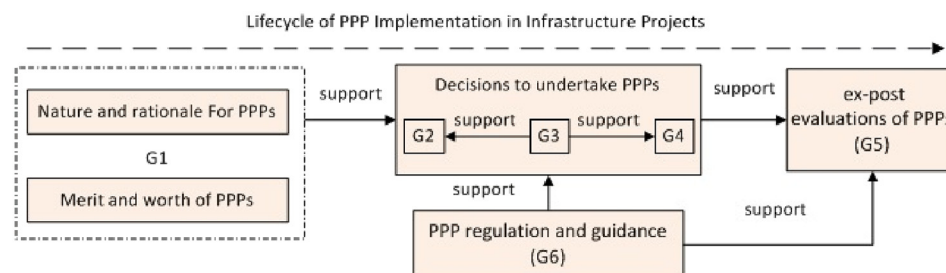


Fig. 7. Relationship among research groups.

between the six research groups and categorized research topics are showed in Fig. 7. Group 1 provides a foundation and supports decisions to undertake PPPs, while decisions to undertake PPPs supports the ex-post evaluations of PPPs. PPP regulation and guidance is another foundation that supports both the decisions to undertake PPPs and the ex-post evaluations of PPPs.

**6. Research gaps and research directions**

As discussed above, the extant body of literature on PPP research has enabled advances in the practice of PPP infrastructure projects. Nevertheless, there still are some problems and deficiencies in the PPP theory and practices pertaining to infrastructure projects. To achieve success in PPP projects, the framework in Fig. 8 must be considered that indicates the effect of the research topics, which are summarised in recent research, as well as the problems and deficiencies that are shown in dotted lines. Concerning the decision process in PPPs, the economic feasibility and value for money evaluations are the key methods involved in the selection and scoping of PPP projects. This selection does not consider public attitudes and other stakeholders’ expectations. However, public opposition has been reported as the main reason for the failure of PPP projects in some instances (Henjeweile et al., 2013). Because of great influence to VFM evaluation and economic feasibility evaluation, there needs to be a focus on well-structured risk management and feasible decision methods necessary to improve performance of PPPs (Yuan et al., 2009). Improving sustainability performance is an important target when developing PPP infrastructure projects, and the sustainability quantitative appraisal still needs further exploration to ascertain ways that can be employed to improve the sustainability performance of PPP projects (Shen et al., 2016). Owing to the changing nature of PPP projects, rigidity contracts need ‘overwriting’ contract clauses to decrease the number of unexpected situations. Additionally, there needs to be a solution on facilitating the establishment of flexible contracts (Cruz and

Marques, 2013). Additionally, the efficiency of contract negotiation and renegotiation in facilitating flexible contracts should also be explored and improved in the future (Xiong and Zhang, 2016). PPPs’ inefficiency is sometimes attributed to deficient regulation and overregulation of the government, while a way to achieve efficiency in PPP governance should be highlighted as a topic for future research (Mouraviev and Kakabadse, 2015). In summary, the main body of knowledge for PPP and guidance on PPP projects implementation, research on how to manage knowledge, and filling the apparent knowledge gaps in PPP projects remain relatively underdeveloped (Aerts et al., 2017). In summary, this review identifies research gaps and research directions as follows.

*6.1. Social impact assessment for project selection*

Private participation in infrastructure projects can sometimes improve quality and expand the coverage of key public services. The economic feasibility and VFM evaluations are key methods involved in the selection and scoping of PPP projects, which pay more attention to economic effects rather than social effects. Despite this, PPP projects often attract public and other stakeholders’ opposition because of perceived lower quality, higher price, and lower-than-expected private sector performance (Ameyaw and Chan, 2013). Public opposition has been reported as the main reason for the failure of PPP projects in some instances (Henjeweile et al., 2013); however, public attitudes and expectations have not received much consideration during the decision process for PPPs. Physical infrastructure is a basic requirement that ensures smooth functioning of economic and social life. Hence, lack of proper infrastructure creates grounds wherein infrastructure projects are subject to strong external forces such as attracting public distrust. However, this negative aspect is offset by the potential of such projects to improve travel convenience, raise living standards, and improve employment rates.

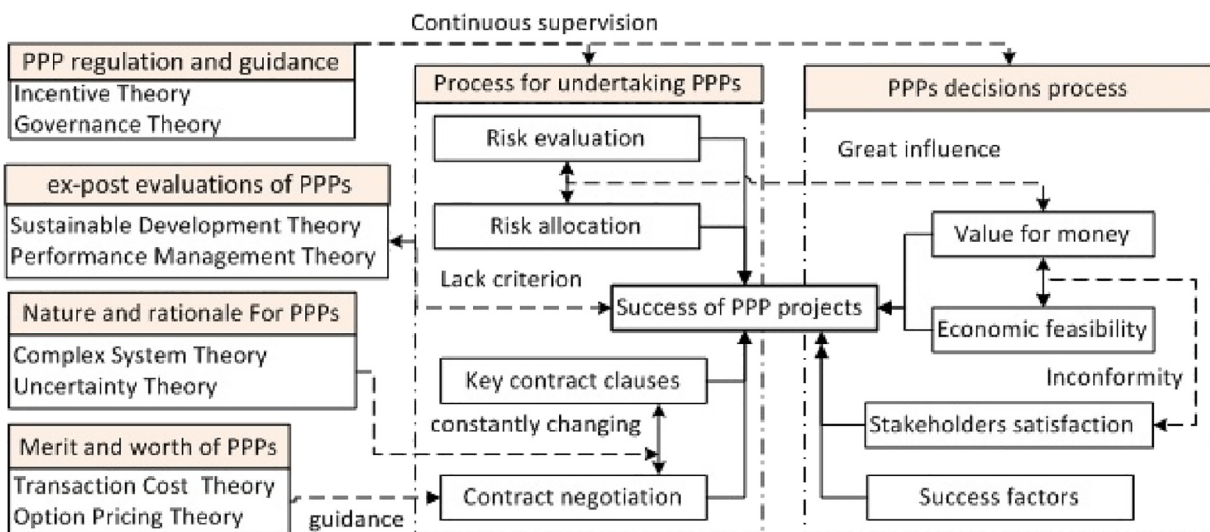


Fig. 8. Research gaps framework based on research topics.

There have been many existing methodologies and techniques to select appropriate projects where PPP can deliver more efficient outputs, such as financial evaluation, economic evaluation, and value for money assessment. Social impact assessment is significant for PPP projects, but has been largely ignored during the development of PPP projects and is given little coverage in academic studies. As a popular PPP project selection method, VFM assessments focus on the economic effects of projects in isolation. To improve PPP project selection methods, social impact evaluation systems should be established to identify and evaluate the differences of social impact between traditional procurement and PPP. We suggest that social impact should be considered and evaluated prior to project selection, according to different applications of PPP in the infrastructure domain. The study of social impact evaluation indicators and evaluation methods should become a mainstream feature of research in this area to fill this gap.

Furthermore, environmental impact assessment systems should become an integral part of the PPP project selection process. In view of the long lifecycle and long-term impact on the local finance of PPP projects, intergenerational impact effects should be evaluated. We predict that the evaluation process, index, method, standard of social impact, environmental impact, and intergenerational impact on PPP projects will attract the attention of many researchers in the future.

### 6.2. *Efficient risk management to perfect the PPP decision process*

Exiting great influence to value for money evaluation and economic feasibility evaluation, risk evaluation and allocation also impact performance of PPPs directly. In PPP projects, it is understood that VFM should include initial cost, risks assessment, and competitive neutrality with qualitative and quantitative techniques (Ameyaw et al., 2015). A comprehensive evaluation and reasonable allocation of risks will help forestall any future stakeholder agitation against PPP projects (Pitt et al., 2006). Researchers have taken further steps to ensure greater transparency in the VFM assessment by introducing workshops that bring experts, public officials, and consultants to identify and categorise risks, allocate risks, estimate probability and cost, and quantify risk value (Ameyaw et al., 2015). There still are some high-risk influences (e.g. political risks and usage risks) in PPP projects that can negatively impact VFM achievement (Henjeweale et al., 2011).

The researchers must assess the considerable risks that emerge from the considerable uncertainties in the infrastructure projects. Successful project implementation during the entire lifecycle of a project would clearly demand effective management and proper allocation of risk. Systematic risks would be allocated to the sector that can manage it more effectively to maximize the chance of improving the performance of PPP projects (Wamuziri and Clearie, 2005). To improve risk evaluation and risk allocation methods, we suggest that the identification and evaluation of risks should be quantified systematically and individually based on the nature of project type, project implementation stage, and background of the

project location, among others. The study of well-structured risk management and feasible decision methods should become a mainstream feature of research in this area as a means to fill the stated gap.

### 6.3. *Performance appraisal criterion for the sustainability of PPP projects*

Private sector not only provides funding for infrastructure projects but also contributes its expertise towards engendering innovation and developing a sustainable asset. Hence, improving sustainability performance should be an important target for developing PPP infrastructure projects. Sustainability performance appraisal of PPP projects has attracted several researchers who aimed to perfect economic, social, and environmental performance criteria in examining project feasibility (Shen et al., 2016). Various effective appraisal models and useful methods for optimising have been proposed, and sustainable assets of various types of infrastructure projects with improved maintenance have been set up to improve the theory and method of sustainability performance appraisal of PPP projects (Love et al., 2015). Sustainable development, sustainable viability, and sustainable profitability have proved to be the most highly emphasised indicators in performance management and in the measurement of PPP projects (Yuan et al., 2012).

However, there is still a lack of formal, systematic, and operational measures to evaluate the PPP performance if the outputs are sustainable for a long-term contractual period (liu et al., 2016a). The delivery of VFM should rely on long-term project performance at a high level, which would sustainably benefit the expanded development of PPPs (Sobhiyah et al., 2009). Nevertheless, in some PPP projects, the overall cost to achieve the perceived positive performance is unsustainable. Some projects broaden the scope during implementation in response to the new sustainability agenda; this resulted in inconsistent performance of infrastructure projects (Henjeweale et al., 2014). Therefore, the key to achieving real sustainable performance lies in recognising the entire responsibility, undertaking a comprehensive analysis, and proposing acceptable price from the very beginning of PPP projects (Hodge and Greve, 2007). Additionally, minute details that involve the sustainability and persistence of PPP projects should be considered (Páez-Pérez and Sánchez-Silva, 2016). In addition, the PPP project proponents should make an adequate and sustained marketing campaign to ensure that the publics can be creative in designing financial packages and in resource allocation to improve PPP performance and sustain competitive advantage (Yuan et al., 2009).

In response to the lack of performance appraisal criterion for sustainability of PPP projects, suggestions for future research are as follows: (1) Sustainability quantitative appraisal criterion still needs further exploration, and studies must be conducted to examine ways of improving the sustainability performance of PPP projects; (2) Sustainable marketing campaign environment should be the main focus of future research; and (3) sustainability performance must be maintained during the whole period and



minute details that involve the sustainability of a PPP project should be considered in future research.

#### 6.4. Improved methodology for flexible contracting

PPP contracts are long-lasting and constantly changing. The rigidity of contracts suggests that they are unable to adapt to great uncertainty during the lifecycle of a PPP project. This has led many practitioners to invest enormous efforts in ‘overwriting’ contracts to decrease the number of unexpected situations (Cruz and Marques, 2013). Flexible contracts are more suitable when it comes to dealing with uncertainty, and represent a sensible approach for PPP projects. As per findings, only 10 out of the existing 754 studies employ methodologies to show how to establish a flexible contract and how to concede in renegotiation.

Although the terms of ‘flexible contract’ and ‘renegotiation’ introduce various alternative methodologies or guidelines, they are still at a nascent stage and offer enormous scope for refinement. Among these 10 studies, 8 studies focus on renegotiation methods and processes, while 2 studies focus on renegotiation triggers and contractual flexibility analysis. Unlike suggestions on how to deal retrospectively with renegotiation following a PPP contract conflict during the lifecycle of a PPP project, proactive measures, such as analysis of renegotiation triggers and flexible contract terms before contract conflict, have attracted little attention of scholars. This could be because many stakeholders of PPP projects pay more attention towards protecting their interests, rather than benefitting the overall project when contract conflicts occur. Concerning the use of methods, the game and real option theories have been more frequently used; however, the win–win theory and synergy theory have garnered lesser attention, despite their apparent applicability to PPP project management. Essentially, considering both stakeholders’ interest and project’s success, we suggest that an important area of research should be to combine strengths from existing methodologies to explore contract flexibility classification and measurement, flexible contract terms, dynamic contract supervision, and renegotiation triggers, among others. In addition, the lack of targeted research on different types of infrastructure projects and specific regions can lead to incomplete or inaccurate frameworks for flexible contracts. Further research across these various project types and regions are necessary to expedite renegotiation frameworks and build flexible contract application.

In response to the lack of a mature methodology for flexible contracting, suggestions for future research are as follows: (1) Private sector companies play an important role in PPP application. The private sector must explore the method of partner selection and the assessment of their competency in the future; (2) As the main target of contract management, the cost of negotiation and renegotiation during the full lifecycle of a project should be scientifically reduced. Alongside this, the efficiency of contract negotiation and renegotiation in achieving flexible contracts should be explored and improved in the future; and (3) Despite several real and perceived obstacles, we suggest that perfecting the mechanism of flexible contracting should remain the main focus of future research. It should also

include specific topics, such as contract terms, trigger conditions, renegotiation time-points, and other associated criteria.

#### 6.5. Government supervision of PPP projects

Governments support the development of PPPs with clear policies, political commitment, and appropriate legal and regulatory frameworks, which provide a stable and reasonable cooperation environment for the public and private sectors. Moreover, trust between public and private actors is fostered by clear regulations, standards, clear roles of public actors, and ex-ante evaluation (Verhoest et al., 2015).

Good governance institutions, specifically good regulatory quality, bureaucratic efficiency, and independence, enhance PPP performance; this is evident from their positive effect on investment growth. However, the lack of certain critical ingredients of good governance has a direct and negative impact on the fulfilment of PPP potential (Hayllar, 2010). Good governance and regulatory quality have become important governance variables to facilitate private investment and improve the capability of governments (Sabry, 2015). During the long-term contractual period of PPP projects, changing government regulation can lead to a difficulty in managing diverse risks associated with government actions and supervision difficulty (Wibowo and Alfen, 2015).

Regulatory quality should focus on not only irregularities in the PPP legal framework and overregulation of government but also focus on flexible supervision and the regulation of government. We suggest the following to improve the regulatory quality of PPP projects. First, practitioners and researchers should emphasise on deregulation trends of government to transform the regulatory landscape of infrastructure projects and strengthen collaborative partnerships between industries and regulators and other policymakers (Koliba et al., 2014). Second, practitioners and researchers have to be concerned with ways to reduce the government’s overregulation of private operators; this might lead to greater PPP flexibility in management and, ultimately, higher efficiency when delivering the public services (Mouraviev and Kakabadse, 2015). Third, subsequent PPP studies must examine the policy diffusion and transfer processes from a formal to an informal framework to understand the spread of PPP-supporting policies, regulations, and other arrangements and to understand how these elements serve as barriers to the development of infrastructure PPPs (Verhoest et al., 2015).

#### 6.6. Knowledge management methods for PPP projects

Concerning public sector actors within PPP projects, state and local governments possess little experience of working in PPPs (Boyer, 2016). Although some national or regional level offices for collating lessons learnt and advising on the implementation of PPPs have been established in some developed countries, there is still an urgent need for more training related to the development of PPPs, particularly among the public sector procurement teams (Wang et al., 2016). A more developed and complete knowledge management system could provide a baseline and reference standard to check skills

of public sector PPP teams. The major knowledge gaps considered in PPP projects are areas concerning with financial risk allocation, public involvement, consultant management, and information imbalances (Boyer, 2016). An exploration of what kind of knowledge management approach can contribute towards filling these knowledge gaps should be explored in the future. Consequently, this would improve the capacity of public sector for developing PPPs.

Although publications metrics in the form of citation counts and measures of impact have long been used as indicators for knowledge creation and research output, systematic knowledge management research is still inadequate. A considerable amount of research has shown the importance of knowledge management (Nissen et al., 2014; Tahat, 2014), but research on how to manage knowledge and fill the apparent knowledge gaps in PPP projects remains relatively underdeveloped. It is suggested that additional studies should be carried out to apply and develop methods to enhance knowledge management such as knowledge sharing, knowledge spillover, and knowledge ontology building.

PPP projects are very information-intensive, partially due to a large number of stakeholders from different disciplines. Several processes must be completed simultaneously within strict timelines, and a plethora of documents must be generated by different software or systems across every PPP project. In response to deficiencies in knowledge management methods for PPP projects, we suggest the following solutions. First, effective information integration methods are very important to achieve high-efficiency PPP project management, and hence should be studied in the future. Second, more studies on the application and development of knowledge management methods, including knowledge sharing and knowledge spillover, must be conducted. Third, scholars should turn their attention to the study of knowledge ontology building and its application.

## 7. Conclusions

Due to the growing interest in the research and application of PPP procurement, this study presented a detailed review of the status quo, gaps, and research suggestion for the future of PPP research for infrastructure projects. The main contributions of this study are fourfold. First, the overview of PPP researches is based on the title of the study, publication year, journal title, country or region where the studies are conducted, project types, disciplines of the screened studies, and selection of the research articles. Theoretical foundations of PPP research in disciplines is set up to analyse the main theoretical foundations and special theories. Second, unlike most preceding literature reviews, this review is guided by a systematic process. It combines a three-phase word frequency analysis, cluster analysis, and an assessment of potential research topics. This process helps to summarise the appropriate topics related to PPP and to overcome some of the arbitrariness and subjectivity involved in research topic analysis. The word frequency and cluster analyses, which have a higher degree of similarity on the basis of the occurrence and frequency of words, are clustered

and used to explore the status quo and research topic more quantitatively. Third, six research topics are explored, including financial package and PPP application, economic viability and VFM, risk management and success factor, procurement and contract management, performance management, and governance and regulation. In addition, relationship between different research groups is analysed, based on the theoretical foundations framework. Fourth, a research gaps framework is set up, based on research topics and the theoretical foundations of PPP research. On this basis, several research gaps are identified and research directions are provided. The methods for conducting word frequency and cluster analyses together with the process of research gaps identification, based on the systematic theoretical analysis, reduce subjective judgment in current research effectively. The findings can provide some conclusions on the status quo of PPP research and guide researchers in selecting the research topic in the future.

Although the current study contributes to the literature on PPP infrastructure projects research by summarising research topics and exploring research gaps, it also has some limitations that need to be addressed by conducting further research. First, there are undoubtedly other PPP types being practiced in PPP infrastructure projects, such as BOO, BOOT, and ROT. Second, although literature that include ‘infrastructure’ in the full text were searched, some studies on PPP infrastructure projects are not included in the study because the word ‘infrastructure’ did not appear in the study.

## Conflict of interest

There is no conflict of interest for this research paper.

## Acknowledgments

This work was supported by the National Natural Science Foundation of China (71672180), the Social Science Foundation of the Hebei Province in China (HB16GL066), and the Natural Science Foundation of the Hebei Province in China (E2017508093).

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