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Systematic analysis of PPP research in construction journals: from 2009 to 2019

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Abstract

Purpose – The aims of this study are to conduct a systematic review of public–private partnership (PPP) studies published from 2009 to 2019, to compare the results with Ke *et al.* (2009) who reviewed the PPP literature published from 1998 to 2008, and to trace the evolution of the PPP knowledge in the past two decades. This study also presents the possible directions that the PPP research may go towards in the future, arguably.

Design/methodology/approach – This study carried out a top journal-based search to identify the quality PPP articles published from 2009 to 2019. A total of 12 top-tier construction journals were systematically searched in the database of web of science (WOS), from which 279 PPP articles were identified for review.

Findings – The number of the identified articles, the titles of the journals, institutions, the most cited papers, and prevalent research methods were analyzed and compared. The existing PPP studies in construction journals were classified into seven streams. Through analysis of the PPP research status and gaps, five future research directions were revealed.

Originality/value – This study contributes to the current body of knowledge by revealing the research trend of PPP from 2009 to 2019. It presents the change of PPP development trend in the past decade through comparison with Ke *et al.* (2009). It also reveals the major research streams and points out the directions that the PPP research may go towards in the future. Moreover, this study is helpful to the practice as well. It can enhance the practitioners' understanding of the PPP development in the past decade. In addition, it identified the research institutions contributing the most in the area of PPP, which may serve as valuable reference for practitioners to locate the best institutions for consultancy or collaboration.

Keywords Public-private partnership, Review, Comparison, Construction industry

Paper type Literature review

1. Introduction

PPP aims to provide an asset or a service under contractual relationships between public sectors (governments) and private sectors (Tang *et al.*, 2013). It is a procurement approach or model to deliver essential public services crossing various sectors and increase the economic value of outputs (Song *et al.*, 2013; Cui *et al.*, 2018). PPP has been widely used to deliver public infrastructure, services, or both since the 1990s (Love *et al.*, 2015; Song *et al.*, 2016; Liu *et al.*, 2014a, b, c). As an increasingly important procurement approach in developed and developing countries, PPP application has been established in the following sectors: transportation, environmental protection, energy, public housing, security, public health and

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education (Buse and Harmer, 2007; Siemiatycki and Farooqi, 2012; Song *et al.*, 2013; Cruz and Marques, 2014; Hernandez-Aguado and Zaragoza, 2016).

Alongside the rapidly increasing influence of private participation in public infrastructure development, research interest and articles relevant to PPP have proliferated (Al-sharif and Kaka, 2004). The development of the knowledge system of PPP has enabled researchers to share and gain access to these research findings, investigate the status quo and explore future trends in the subject area. Therefore, a systematic analysis of published articles in academic journals would be valuable to the research community (Tsai and Wen, 2005; Ke *et al.*, 2009).

Several PPP reviews have already been carried out in the past two decades, summarizing the PPP research development process and revealing trends of PPP research. For example, Al-sharif and Kaka (2004) analyzed 34 Private Finance Initiative (PFI) related articles from 1998 to 2003 selected from the following four major academic journals: Journal of Construction Engineering and Management (JCEM-Construction), Construction Management and Economics (CME), International Journal of Project Management (IJPM), and Engineering, Construction and Architectural Management (ECAM). Song *et al.* (2016) presented 1,036 articles and conference papers from the web of science (WOS) core collection database with publication dates between January 2000 and July 2015 using Cite Space software to visualize emerging trends and changes. Some scholars also reviewed PPP research literature from a specific viewpoint. Based on the perspective of project life cycle, Bao *et al.* (2018) conducted a systematic review of the PPP publications selected from seven leading construction management journals (JCEM-Construction, IJPM, CME, Journal of Management in Engineering (JME), Journal of Infrastructure Systems, ECAM, Proceedings of Institution of Civil Engineers-Civil Engineering (PICE-CE)), which is informative for scholars to pay attention to problems in varied PPP phases. Moreover, some studies have reviewed the specific problems encountered in the implementation of PPP projects, such as critical success factors (CSFs) (Osei-Kyei and Chan, 2016; Zhao *et al.*, 2013), residual value risk (Yuan *et al.*, 2015) and critical decision factors of PPP concession (Ullah *et al.*, 2016). Ke *et al.* (2009) reviewed articles published in seven renowned construction journals. Based on a two-stage literature review, Ke *et al.* focused on the following information: the annual number of PPP articles published, contributions of writers to the papers and research interests in PPP. The contribution of writers to the papers incorporates country origins, affiliation, and citation analysis. The work of Ke provided a significant and informative overview of the PPP development from 1998 to 2008. Nevertheless, after a decade of development, changes might occur to the PPP development in the construction field. Thus, this study is determined to review the PPP articles published in the past ten years and to carry out a comparative analysis with Ke *et al.* (2009).

This study identified 279 PPP articles published in 12 high-quality construction journals between 2009 and 2019. The result of this study was compared with that of Ke to visualize the processes of development and change in PPP research. This study intends to provide a unique overview of the PPP research status for future exploration in the construction domain by addressing the following questions:

(1) What are the main changes in the PPP research in the area of construction between the periods of 1998–2008 and 2009–2019?

(2) What are the major streams of the PPP research from 2009 to 2019?

(3) What directions will the PPP research go towards for the future?

2. Methodology

This study conducted a systematic literature review of PPP articles published in 12 top-tier construction journals to learn the research progress on the global development of PPP. A

systematic review aims to collect and analyze the past academic articles and find answers to the research questions (Le *et al.*, 2019). This method is suitable for establishing an overview on an issue, hence bringing scholars and practitioners evidence-based insights about a certain topic or research problem (Petersen, 2019). Therefore, in order to build a structure of quantitative summary in PPP research, the current study conducted a systematic analysis of the publications in selected construction journals, contributing to the collection of the following information: the number of articles, journals, research origins, institutions, research streams, research methods, and cited articles. Different from the two-stage literature review of Ke *et al.*, this study adopted a research approach that comprises three main steps: identification of academic journals, selection of target articles, and examination of the target articles. As shown in Figure 1, Stage 1 covered the determination of journals, search engines,

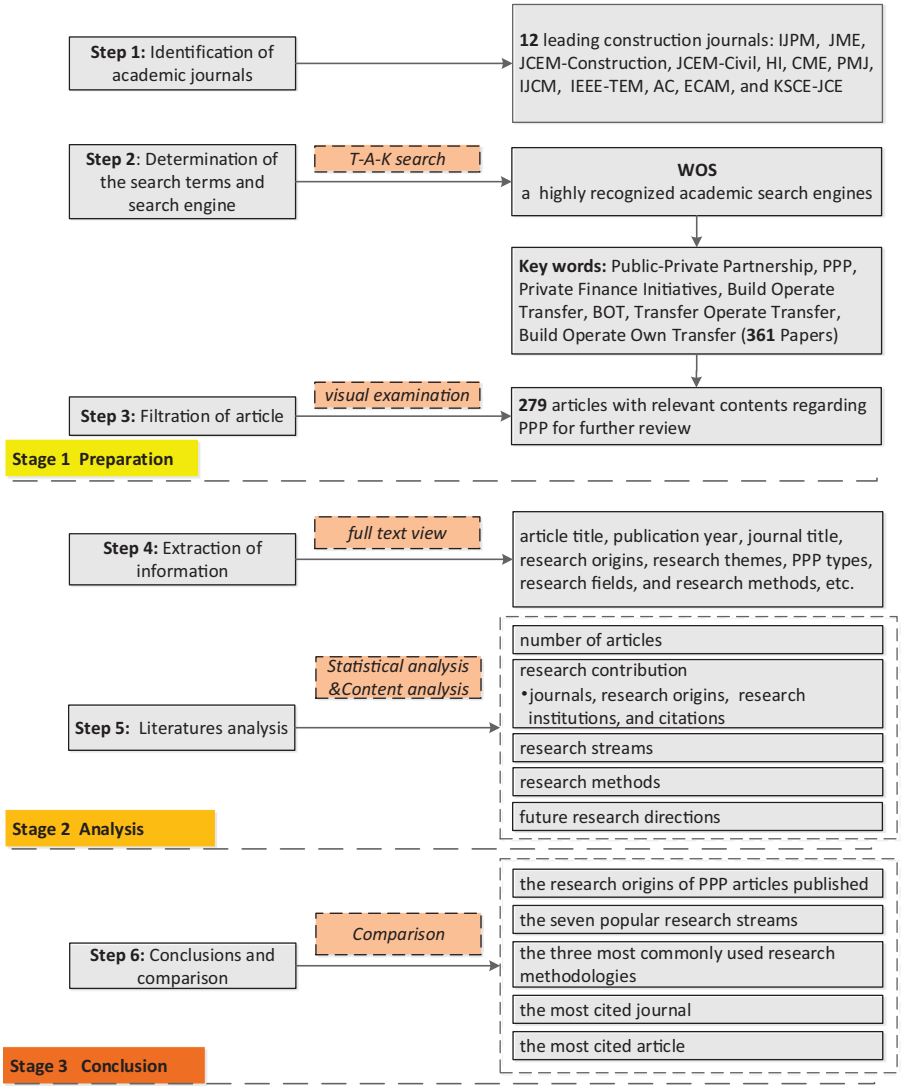

Figure 1.
Flow of overall research framework

and search terms. An analysis of filtered articles was conducted in Stage 2, laying a foundation for the exploration of existing research gaps. A conclusion based on the analysis in Stage 2 was presented in Stage 3. The research procedure for articles related to PPP research involves the following steps of the three stages.

2.1 Stage 1: Preparation

Step 1: Identification of academic journals. PPP articles reviewed in this study were identified from 12 top-tier construction journals, namely IEEE Transaction on Engineering Management (IEEE-TEM), Automation in Construction (AC), International Journal of Project Management (IJPM), Project Management Journal (PMJ), Journal of Construction Engineering and Management (JCEM-Construction), Construction Management and Economics (CME), Journal of Management in Engineering (JME), Engineering, Construction and Architectural Management (ECAM), Journal of Civil Engineering and Management (JCEM-Civil), Habitat International (HI), International Journal of Construction Management (IJCM), and KSCE Journal of Civil Engineering (KSCE-JCE). These journals were selected as the target journals for literature search based on the construction journal ranking of Chau (1997) and the recommendations of several PPP reviews published previously (Al-sharif and Kaka, 2004; Ke *et al.*, 2009, Tang *et al.*, 2010; Utama *et al.*, 2016, Zhang *et al.*, 2016).

Step 2: Determination of the search engine and terms. The list of publications was obtained by using a powerful and highly recognized academic search engine, namely, "WOS," for a comprehensive search on the subject area (Le *et al.*, 2014; Cui *et al.*, 2018). WOS was extensively used due to its comprehensiveness and scientific nature (Neto *et al.*, 2016). The search terms included "Public–Private Partnership or PPP or Private Finance Initiatives or Build Operate Transfer or BOT or Transfer Operate Transfer or Build Operate Own Transfer" to analyze and summarize the research status of PPP from 2009 to 2019. Publications with these specific terms in the search title, abstract, and author keywords were considered to have satisfied the research requirements. The publication name was also defined according to the 12 selected journals. The full search code is as follows (one of the examples):

TOPIC: (Public–Private Partnership or PPP or Private Finance Initiatives or Build Operate Transfer or BOT or Transfer Operate Transfer or Build Operate Own Transfer) PUBLICATION NAME: (Engineering, Construction and Architectural Management) Timespan: 2009 to 2019. Databases: WOS, BCI, KJD, MEDLINE, RSCI, SCIELO. Search language = Auto

Step 3: Filtering of articles. Among the 361 articles obtained from the literature search, some might not be relevant to the topic of this study. Hence, a careful visual examination was conducted to the 361 articles following the CASP Checklist to appraise their relevancy to the topic of the study. Lastly, a total of 279 valid articles were kept for the further review.

2.2 Stage 2: Analysis

Step 4: Extraction of information. The extrication of information on article titles, key words, or abstracts that do not provide adequate details was based on the full-text view. The information includes article title, publication year, journal title, country or region where the studies were conducted, research streams, PPP types, research fields and research methods.

Step 5: Literature analysis. Statistical and content analyses were conducted on the basis of information from Step 4. The number of articles and research contributions (including journals, research origins, research institutions, and citations) were analyzed through statistical analysis. The content analysis revealed the research status of these popular topics on PPP and research gaps. The methods adopted to explore PPP research development were also summarized in this step.

2.1 Stage 3: Conclusion

Step 6: Drawing a conclusion based on the literature analysis of Stage 2 and conducting comparison with the finding of Ke *et al.* (2009) to reveal the changes in PPP research trend of construction industry in the past two decades. Concentrating on the two periods, 1998–2008 and 2009–2019, this study went through annual number of articles, the quantity of articles and number of citations of five common journals, research origin, active researchers, and research streams, which were discussed in this section.

3. Literature analysis

3.1 Number of articles

The annual number of publications from the selected journals from 1998 to 2019 was presented in Figure 2. The figure shows an increasing trend of research interest in PPP in the past two decades. It can be seen that rapid increase in publication began in 2010. This trend steadily progressed to a small peak of 40 publications in 2015. In 2016 the number of PPP publications decreased but it recovered from 2017 and remained on the uptrend until the present. Generally, comparing the number of the publications of 1998–2008 and 2009–2019, it can be found that more PPP articles were published in the recent decade. This is mainly because in the past ten years PPP was increasingly recognized, adopted and promoted by more and more countries or administrations in the world, and accordingly, more academic publications in this area were produced.

3.2 Research contribution

The research contributions of the identified articles were analyzed from the following aspects: journals, which journal published the most PPP literatures; countries or regions, in which country/region PPP is a popular research topic; and research institutions, which institution is predominant in PPP research. This information is useful to researchers, particularly for their potential collaborations in the future (Al-sharif and Kaka, 2004). In addition, citation analysis of selected articles is considered significant for the assessment of the authors' and journals' contributions (Ke *et al.*, 2009). Thus, citation analyses of the identified articles were conducted and presented in this section as well.

3.2.1 Top contributing journals. Table 1 presents the number of the PPP articles published by the 12 journals from 2009 to 2019. JME, IJPM and JCEM-Construction published the most PPP articles. All of them published more than 50 PPP articles in the past decade. Particularly, JME favors PPP research the most, as 7.48 percent of the articles published by the journal in the last ten years were regarding PPP.

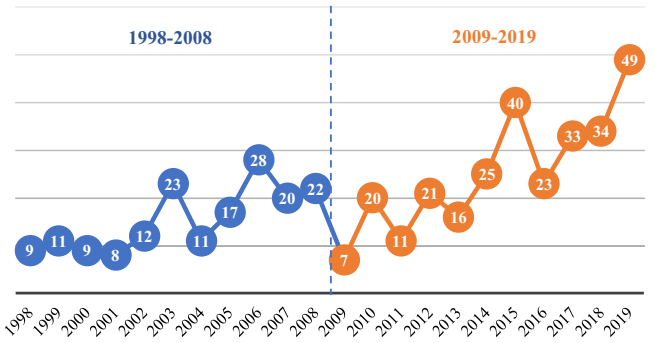

Figure 2.
Number of relevant articles published annually in the selected journals from 1998 to 2019

Journal title	Number of articles (PPP)	Number of articles	Ratio (%)
Journal of Management in Engineering (JME)	55	735	7.48
International Journal of Project Management (IJPM)	54	1150	4.70
Journal of Construction Engineering and Management (JCEM-Construction)	53	1527	3.47
Journal of Civil Engineering Management (JCEM-Civil)	26	864	3.01
Construction Management and Economics (CME)	20	329	6.08
Engineering, Construction and Architectural Management (ECAM)	19	397	4.79
International Journal of Construction Management (IJCM)	16	281	5.69
Habitat International (HI)	11	1284	0.86
Project Management Journal (PMJ)	9	663	1.36
Automation in Construction (AC)	7	1989	0.35
KSCE Journal of Civil Engineering (KSCE-JCE)	7	2846	0.25
IEEE Transaction on Engineering Management (IEEE-TEM)	2	608	0.33

Table 1.
PPP articles published in selected journals from 2009 to 2019

In Ke *et al.* (2009), the top three journals that published the most PPP articles between 1998 and 2008 were JCEM-Construction (40), CME (32), and IJPM (30). Comparing these numbers with the results obtained from the current review, it can be found that more PPP articles were published in the top contributing journals in 2009–2019. To support the claim further, the research team compared the number of the PPP articles published by the top five contributing journals that are commonly shared by Ke *et al.* (2009) and the current review. The comparison results were plotted in Figure 3, which shows that four out of the five journals (i.e. JME, IJPM, JCEM-Construction and ECAM) received increment in the number of PPP publications.

3.2.2 Research origin. A summary statistic of articles published in countries and regions was conducted to ascertain countries with the most PPP studies. The research origins of the selected PPP articles cover 40 countries and regions. The map of countries and regions origins of PPP articles (more than four articles) is presented in Figure 4, and the active research areas were mainly in Europe and Asia. The PPP development in Europe started early, laying a foundation for PPP-related research. Although the PPP development in Asia

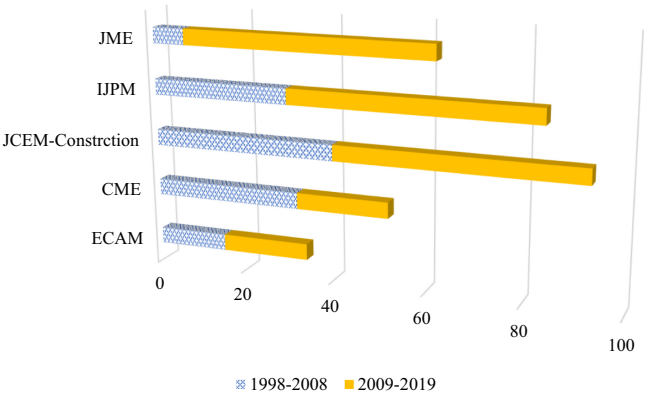

Figure 3.
Comparison of number of articles related to PPP in journals of ECAM, CME, JCEM-Construction, IJPM and JME between the period of 1998–2008 and 2009–2019

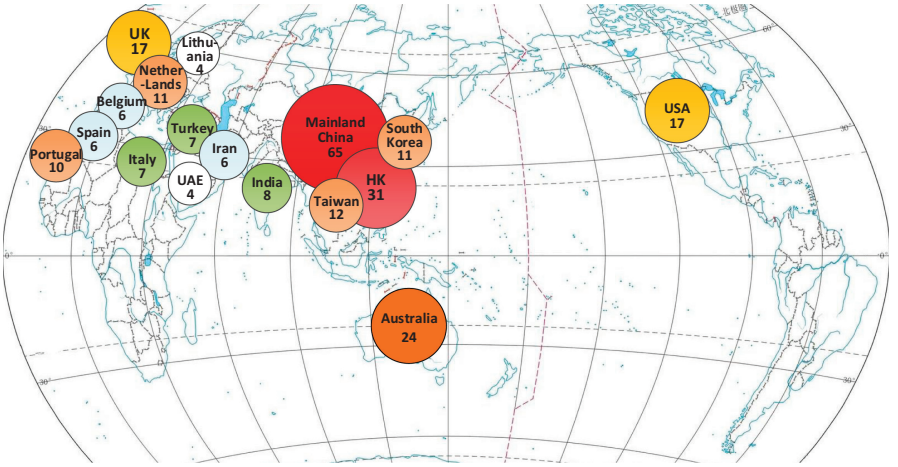

Figure 4. Regional distribution of PPP published articles from 2009–2019

started relatively late, studies on PPP were abundant. By contrast, additional PPP practice projects were implemented in Asia. The majority of PPP articles were concentrated in Mainland China (65). This finding is expected because an increasing number of PPP usage for the provision of infrastructure promoted by the central government of China has been observed (Zhang *et al.*, 2018). Hong Kong (31) ranked second for abundant international experiences of PPP project and dominated the field of PPP research (Osei-Kyei, and Chan, 2016; Cui *et al.*, 2018).

As demonstrated in Figure 5, comparing with the results of Ke *et al.* (2009), Mainland China, South Korea, Portugal, Spain, Iran and Belgium published more PPP articles in 2009–2019 than they did in 1998–2008. Particularly in China, much more research publications were produced in 2009–2019. An important reason behind this increment is that considerable

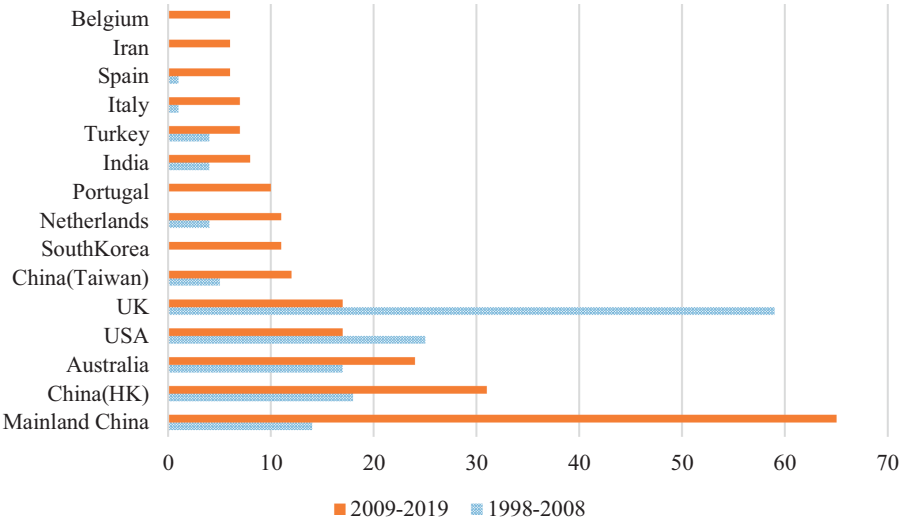

Figure 5. Comparison of research origins of PPP published articles between the period of 1998–2008 and 2009–2019.

efforts were put in PPP by the government in the past ten years, which also created a lot of scientific achievements in this field. For example, Ministry of Finance of the People s Republic of China (MOF P.R. China) stated in 2014 that promoting the application of PPP is a major economic reform task and it should be done as soon as possible (MOF P.R. China, 2014). In 2015, provincial and local governments in China were also required by the central government to support the development of PPP in their jurisdictions (State Council P.R. China, 2015). Apart from China, HK and Australia were also steadily growing in PPP publications. However, PPP studies from the UK are currently less than those two decades ago, due to the maturity of the PPP market in the UK (Wang *et al.*, 2018a, b).

3.2.3 Top contributing institutions. Among the 153 research institutions with published articles by researchers on PPP topics, the statistical results of this study and Ke *et al.* (2009) were demonstrated in Table 2 (less than five articles were not listed). The Hong Kong Polytechnic University dominated the list with 19 articles. Southeast University ranked second with ten articles, followed by the Hong Kong University of Science and Technology with eight articles. Four of the top ten were from Mainland China, which played active roles and contributed to Mainland China's ranking first in terms of article counts.

In the findings of Ke *et al.* (2009), the top three were Nanyang Technological University (Singapore), The University of Hong Kong (Hong Kong), and the National University of Singapore (Singapore). In this decade, the Hong Kong Polytechnic University (Hong Kong) and Hong Kong University of Science and Technology (Hong Kong) demonstrated activities in PPP research. This finding could be attributed to the four research teams. The first two teams are from Hong Kong Polytechnic University, including Albert P. C. Chan, Osei-Kyei Robert, Esther Cheung, Tang Liyaning, and Shen Qiping. The members of the last two teams are Zhang Xueqing, Xiong Wei, and Wang Liguang (Team 1) and Zhang Xueqing and Mohsin Ali Soomro (Team 2), who are from the HKUST. Southeast University (Mainland China) also played a significant role in PPP development. In Southeast University, From the aspect of first author, Yuan Jingfeng contributed to eight articles and the other two articles were written by Xu Yelin. There is also a research team which consists of Yuan Jingfeng, Miroslaw J. Skibniewski, and Li Qiming, who collaborated six times; another is Xu Yelin, Miroslaw J. Skibniewski. Albert P.C. Chan who is from Hong Kong Polytechnic University cooperated with them three times.

3.2.4 Citation Analysis. A list of the most cited articles on PPP is created from the articles in this section. The number of citations of an article provides a useful measure of its scientific impact (Badhiwala *et al.*, 2018). The strength of a journal's authority and influence is also primarily assessed in terms of its citation frequency (Song *et al.*, 2016). Understanding the most cited works can guide future research efforts and the all times cited counts were based on the all databases in WOS search engine in this study.

Table 2.
Research institution involving at least five articles

Institution	Articles (2009–2019)	Country/Region
The Hong Kong Polytechnic University	19	Hong Kong
Southeast University	10	Mainland China
Hong Kong University of Science and Technology	8	Hong Kong
Technical University of Madrid	6	Spain
Technical University of Lisbon	6	Portugal
Curtin University	5	Australia
Dalian University of Technology	5	Mainland China
Deakin University	5	Australia
Southwest Jiaotong University	5	Mainland China
Tsinghua University	5	Mainland China

As illustrated in Table 3, the journal with the highest total cites and mean per article cites were the IJPM, which had published 54 articles on PPP research with 2341 times cited. JCEM-Construction and JME ranked second (1312) and third (913), respectively. Seeking for cooperation with the authors or research institutions of highly cited articles is a remarkable opportunity for scholars and practitioners. In the findings of Ke *et al.* (2009), the top three most frequently cited journals were JCEM-Construction, IJPM, and CME, respectively. From the viewpoint of times cited per PPP article, there are overall increases in IJPM, JCEM-Construction, JME, ECAM, and CME. IJPM has the largest increasing range, from 4.50 to 43.35.

Article citation analysis is a statistical method used to reveal the quantity and authority of references cited by published articles. The top ten cited articles of the 279 academic articles are summarized in Table 4. Among these highly cited researchers, Albert P. C. Chan (China-HK), Ke Yongjian (Mainland China) and Wang Shouqing (Mainland China) contributed to six, five, four articles, respectively; both of Yeung, John F. Y. (China-HK), Esther Cheung (China-HK) written two articles. Chan and Ke worked together five times and Wang also cooperated with them four times. According to the findings of Ke *et al.* (2009), Wang *et al.* contributed to four articles in the most frequently cited articles from 1998 to 2008. Wang also appeared three times in Table 4. This appearance indicates that Wang was still active in PPP research in the past decade.

3.3 Research streams

This section attempts to explore the research status of major PPP streams. Based on literature reviews of prior researchers, this study classified the PPP research on topics or themes in the following streams: promotion of PPP, risk management process of PPP, financial issues, contract management, legal and procurement issues, governance and performance issues,

Journal title	Times cited (1998–2008)	Times cited (2009–2019)	Times per article (1998-2008)	Times per article (2009-2019)
International Journal of Project Management (IJPM)	135	2341↑	4.50	43.35↑
Journal of Construction Engineering and Management (JCEM-Construction)	189	1312↑	4.73	24.75↑
Journal of Management in Engineering (JME)	19	913↑	2.71	16.60↑
Journal of Civil Engineering Management (JCEM-Civil)	–	379	–	14.58
Automation in Construction (AC)	–	358	–	51.14
Habitat International (HI)	–	336	–	30.55
Engineering, Construction and Architectural Management (ECAM)	30	109↑	2.00	5.74↑
Construction Management and Economics (CME)	118	107↓	3.69	5.35↑
International Journal of Construction Management (IJCM)	–	88	–	5.50
Project Management Journal (PMJ)	–	53	–	5.89
IEEE Transaction on Engineering Management (IEEE-TEM)	–	37	–	18.50
KSCE Journal of Civil Engineering (KSCE-JCE)	–	12	–	1.71

Table 3.
Journals cited in PPP articles

Author	Year	Title	Times cited
Ke Yongjian; Wang Shouqing; Albert P. C. Chan; and Esther Cheung	2010	Preferred risk allocation in China's public-private partnership (PPP) projects	197
Osei-Kyei Robert; and Albert P.C. Chan	2015	Review of studies on the critical success factors for public-private partnership (PPP) projects from 1990 to 2013	185
Tang Li Yaning; Shen, Qiping; and Cheng, Eddie W. L	2010	A review of studies on public-private partnership projects in the construction industry	170
Albert P. C. Chan; Patrick T. I. Lam; Daniel W. M. Chan; Esther Cheung; Ke Yongjian	2010	Critical success factors for PPPs in infrastructure developments: Chinese perspective	157
Xu Yelin; Yeung, John F. Y.; Albert P. C. Chan; Daniel W. M. Chan; Wang Shouqing; and Ke Yongjian	2010	Developing a risk assessment model for PPP projects in China – A fuzzy synthetic evaluation approach	146
Hwang Bon-Gang; Zhao Xianbo; and Mindy Jiang Shu Gay	2013	Public private partnership projects in Singapore: Factors, critical risks and preferred risk allocation from the perspective of contractors	139
Ke Yongjian; Wang Shouqing; Albert P.C. Chan; and Esther Cheung	2009	Research trend of public-private partnership in construction journals	125
Albert P. C. Chan; Yeung, John F. Y.; Yu, Calvin C. P.; Wang, Shouqing; Ke Yongjian	2011	Empirical study of risk assessment and allocation of public-private partnership projects in China	115
Marques Rui Cunha; and Berg Sanford	2011	Risks, contracts, and private-sector participation in infrastructure	112
Zou, Weiwu; Kumaraswamy, Mohan; Chung, Jacky; Wong, James	2014	Identifying the critical success factors for relationship management in PPP projects	96

Table 4.
Most frequently cited articles

and literature research (Tang *et al.*, 2010; Ke *et al.*, 2009; Chen *et al.*, 2015a, b; Song *et al.* 2016; Zhang *et al.*, 2016). The numbers of selected articles under these streams are presented in Table 5. The classification of research streams may be considered as subjective and dubious judgment (Song *et al.*, 2016). Nonetheless, the classification was conducted by the same researchers, which eliminated adverse impact of variations in views. Even though the article included more than one research stream, the most befitting one was chosen by viewing full text. Therefore, the approach used is appropriate for the analysis and comparison purposes.

The most popular steam of the PPP research in 2009–2019 was the promotion of PPP with 82 articles. Risk management process, legal and procurement issues, and financing issues were ranked second (47 articles), third (45 articles) and fourth places (43 articles), respectively. The sum of the three streams accounts almost 50%. Ke *et al.* (2009) concluded the top seven

Research streams	Number	Percentage	Cumulative percentage
promotion of PPP	82	29.39	29.39
risk management process	47	16.85	46.24
legal and procurement issues	45	16.13	62.37
financing issues	43	15.41	77.78
governance and performance issues	31	11.11	88.89
contract management	21	7.53	96.42
literature research	10	3.58	100

Table 5.
Research streams of PPP articles in selected journals

research interests from 1998 to 2008, which included risk management, integration research, governance issue, investment environment, procurement, economic viability and financial package. As Figure 6 shows, risk events still maintained dominant position due to the prolonged contract periods of PPP projects, resulting in project failures (Rana *et al.*, 2018). Risk management was still a pivotal factor in the PPP project implementation process. Financial issues also attracted broad attention due to the large capital investments in PPP projects. Many scholars also focused on procurement issues for nearly two decades. With the maturity of management technology in PPP practice, there was a downward trend for governance issues. Therefore, the top seven streams were selected for the following review.

3.3.1 Promotion of PPP in the construction industry. Since the 1990s, PPP has played a significant role in developing infrastructure systems in the world (Love *et al.*, 2015). Several previous studies in PPP indicated that PPP projects had been implemented in transportation (Wang, 2015; Ahmadjian and Collura, 2012; Chen *et al.*, 2012a, b; Verweij, 2015), sewer (Lee and Yu, 2011), water industry (Choi *et al.*, 2010), venue project (Liu *et al.*, 2014a, b, c), solid waste collection (Katusiimeh *et al.*, 2012; Ezeah and Osei-Kyei, 2014), community infrastructure (Bremer and Bhuiyan, 2014), and health care infrastructure (Cruz and Marques, 2013). Moreover, assortments of PPP mode, such as Transfer–Operate–Transfer, Build–Operate–Transfer (BOT), Design–Build–Finance–Operate (Jang *et al.*, 2014; Chen *et al.*, 2012a, b), and Design–Build–Finance–Maintain (Verweij, 2015), are available. Selecting the optimum mode to the proposed infrastructure project is the first decision to apply the PPP approach (Zhang *et al.*, 2016).

Although PPP has pervasive promotion worldwide, various problems or barriers have appeared in the promotion process of PPP in many countries (Babatunde *et al.*, 2015). Therefore, some scholars investigated the suitability of PPP projects (Figure 7). For example, Cheung and Chan (2011) constituted an evaluation model for examining the suitability of PPP projects. Ng *et al.* (2010) established an evaluation framework for assessing the feasibility of a PPP project in Hong Kong by applying the structural equation model. Subsequently, Ng *et al.* (2012) suggested that cost-effectiveness and finance attractiveness were crucial to the PPP project feasibility. In addition, CSFs for PPP applications in a specific industry have been identified by a few studies. For example, Nisar (2013) revealed CSFs of the community infrastructure PPP projects by using three cases. Different CSFs were found in different

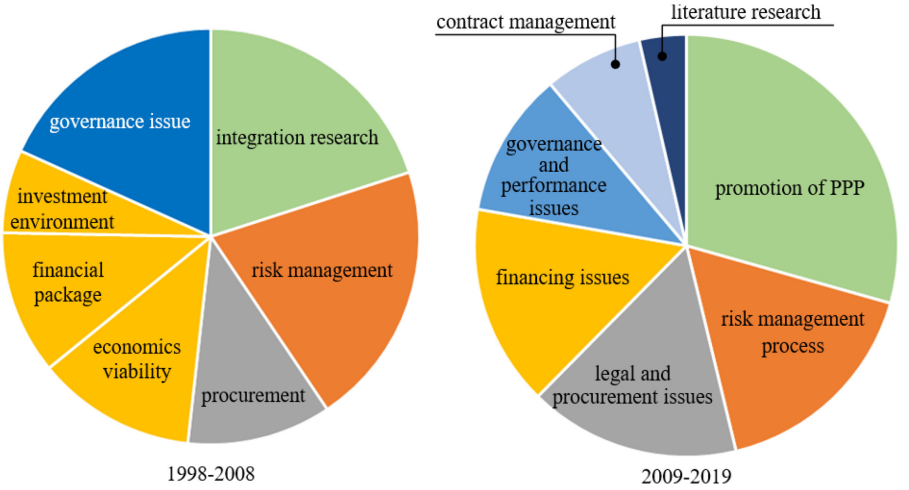

Figure 6. Comparison of research streams of PPP published articles between the period of 1998–2008 and 2009–2019.

countries during PPP applications. Osei-Kyei and Chan (2016) analyzed five CSFs of PPP projects in Ghana, namely, government support, community support, constant communication, project profitability, and capable private partner. In the UAE, the availability and effectiveness of PPP projects were regulatory and legal framework, appropriate risk allocation, clear project brief and client outcomes, comprehensive project feasibility study, and appropriate project value management systems (Al-Saadi and Abdou, 2016). Almarri (2019) analyzed data collected from resident in the UAE and the UK and concluded one of the reasons for its popularity is PPP brings private party's skills and experience to the government and also transfers risk to the private sector.

3.3.2 Risk management process of PPP in the construction industry. Risk is the occurrence probability of a detrimental event by many scholars (Hwang *et al.*, 2015). Several PPP projects have suffered serious risk events due to the increased uncertainties during the prolonged contract periods of PPP projects (Rana *et al.*, 2018), which ultimately led to project failures in the past 30 years (Xiong *et al.*, 2017). Risk management is a key factor in some PPP projects, such as water PPP projects (Shrestha *et al.*, 2018) and transportation PPP projects (Liu *et al.*, 2017). Risk management of PPP has become an increasingly popular topic in recent years (Ke *et al.*, 2012). As shown in Figure 8, risk management is an interactive process of risk

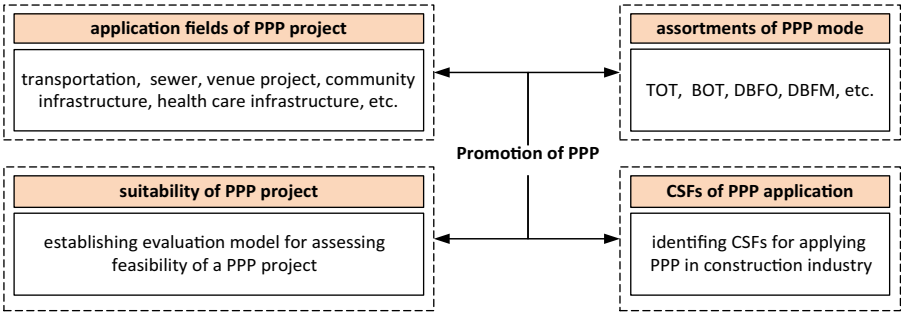

Figure 7.
Promotion of PPP in the construction industry

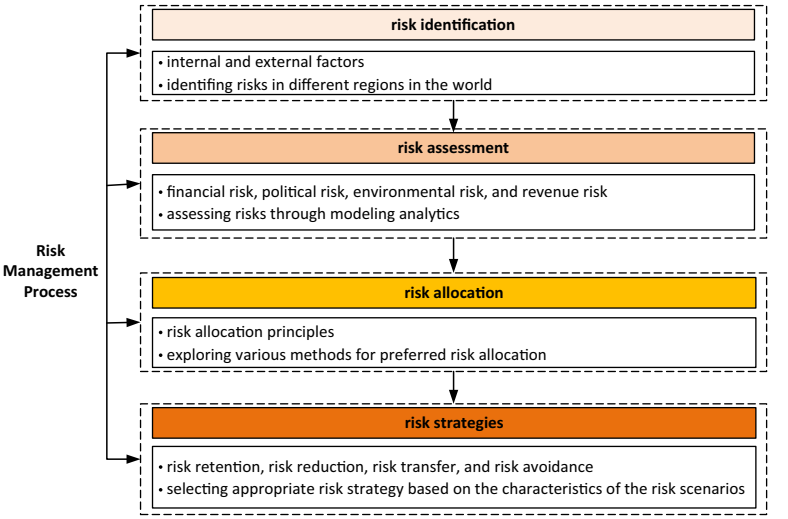

Figure 8.
Risk management process of PPP in the construction industry

identification, assessment, allocation and strategies (Keers and Van Fenema, 2015; Keers and Van Fenema, 2018).

The risk management of PPP projects begins with the identification of risks arising from the inherently complex nature of the project or those from exogenous factors in the external environment of projects (Rebeiz, 2012). Several scholars identified the risks of PPP projects in different regions in the world. For example, Anh Nguyen *et al.* (2018) investigated critical risks affecting the financial viability of PPP toll road projects in Vietnam and grouped them into the following four categories: construction cost-related risks, operating revenue-related risks, operational and maintenance cost-related risks, and financing cost-related risks. Chan *et al.* (2011) found that the three salient risk factors in PPP projects of China were government intervention, government corruption, and poor public decision-making processes through an empirical questionnaire survey. Yuan *et al.* (2015, 2018a, b) identified six potential dimensions of residual value risk (RVR) factors in PPP projects of China, such as downfall of product or service performance, functional problems, decrease in profitability and low possibility of refinancing, deterioration of maintainability, decline in operability and failure of sustainability. Iyer and Sagheer (2010) identified 17 risks in the developmental phase of the PPP project in the Indian road sector. Few scholars considered multiple countries when investigating risk factors for PPP projects. Rebeiz (2012) suggested that the three types of critical risk factors facing a BOOT thermal power plant project in emerging countries were inherent project risks, exogenous project risks and risk factors of emerging markets. In mega transportation projects, Alada and Isik (2019) stated occupational accidents, integration between design and construction phases and excessive design variation are major risk factors, which provided a clue to BOT project practitioners about potential risks.

The risk assessment and allocation are intermediate processes of risk management (Keers and Van Fenema, 2015; Keers and Van Fenema, 2018). Sufficient risk assessment is the basis of effective risk allocation (Mazher *et al.*, 2018). Many researchers conducted risk assessment through modeling analytics, such as stochastic revenue projection model (Liu *et al.*, 2017), interpretative structural modeling (ISM) (Iyer and Sagheer, 2010), Bayesian approach (Wang *et al.*, 2018a, b) and fuzzy set theory (FST) (Mazher *et al.*, 2018; Alireza *et al.*, 2014; Xu *et al.*, 2010). The results of related studies have shown that financial and political risks were the most crucial risk groups (Alireza *et al.*, 2014; Mazher *et al.*, 2018; Iyer and Sagheer, 2010; Xu *et al.*, 2010), whereas environmental and revenue risks most probably occurred in practice (Wang *et al.*, 2018a, b).

Appropriate risk allocation that facilitates a win–win balance for the government and the private sectors is a vital factor in the success of PPP projects (Xu *et al.*, 2010; Shrestha *et al.*, 2018; Alireza *et al.*, 2014). Criteria and principles have been identified by several scholars for the fair distribution of PPP project risks. For example, risk should be allocated to the competent party and distributed to that who prefers to undertake risks (Xu *et al.*, 2010; Chan *et al.*, 2011). The previous studies revealed that some publications explored various methods for preferred risk allocation of PPP projects, such as bargaining game theory (Li *et al.*, 2017a, b), questionnaire survey (Chan *et al.*, 2011; Shrestha *et al.*, 2018), fuzzy set theory (Ameyaw and Chan, 2015), rating scale method (Alireza *et al.*, 2014), reciprocal preference theory (Wang *et al.*, 2018a, b), artificial neural network (Jin and Zhang., 2011) and Delphi survey (Ke *et al.*, 2010).

Risk strategies, namely, risk response, focus on managing risks (Al-Azemi *et al.*, 2014). The response to risks of PPP projects can be classified into the following four categories: risk retention, reduction, transfer, and avoidance (Al-Azemi *et al.*, 2014). The government is considered to be active in formulating risk response measures with the occurrence of severe risk events (Nguyen *et al.*, 2018).

3.3.3 Financial issues of PPP in the construction industry. Considering the large capital investment and long-period of operation of PPP projects, scholars focused on three financial

issues, including project cost (e.g. completion, transaction, and financing costs), project revenue (e.g. price of the services or products, project profitability and government financial assistance) and capital structure, as demonstrated in Figure 9. These issues roughly coincide with several critical economic parameters on PPP as concluded by Zhang *et al.* (2016).

Researchers have studied cost management in PPP projects because it directly influences the price of services or products. Meduri and Annamalai (2013) analyzed the data from 521 public and private road projects in India and stated that developers could take advantage of economies of scale to reduce completion costs of PPP road projects. Ho *et al.* (2015) developed a TCE-based theory and analyzed the opportunism-focused transaction cost. Their analysis indicated that the three major opportunism problems embedded in infrastructure PPP could result in substantial transaction costs. Implementing bond financing decreased the financing cost, which was beneficial to governments, project companies and bond holders in PPP projects with a fairly priced credit default swap (Li *et al.*, 2017a, b). With respect to improve accurate prediction and estimation of the cash flow, Hudson's DHSS model will best fit a construction project (Ross *et al.*, 2013). It was suggested for practioners to adopt the "trial and error" approach and change the parameter value.

Morano and Tajani (2017) proposed a model for price determination using the break–even analysis to define the maximum amount of subsidized housing to be realized by the private investor and the administered selling price to be applied. Ashuri *et al.* (2012) applied real options theory from finance/decision science to determine price minimum revenue guarantee options in BOT projects. Akcay *et al.* (2017) applied Monte Carlo simulation to estimate the net present value considering the relevant risk factors to predict the hydropower investments. In many cases, government economic behavior affects the implementation of PPP project, which influences government finance. As a government financial assistance, the minimum revenue guarantees (MRGs) are a financial aid option that may aggravate economic burden. In Korea, MRGs cost the government US$2.7 billion in liabilities annually. Jang *et al.* (2018) proposed resolving financial conflicts to relieve government economic burden by using a three-phase game framework comprising bargaining, ratification and decision-making phases.

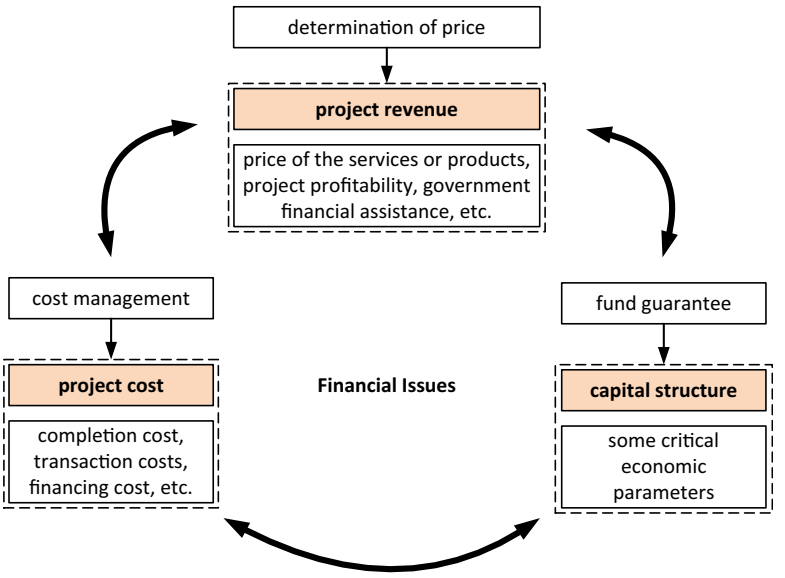

Figure 9.
Financial issues of PPP in the construction industry

Capital structure is the guarantee of sufficient funds of PPP projects (Du *et al.*, 2018) and is also an important factor affecting successful implementations of PPP projects (Feng *et al.*, 2017). Thus, debt ratio is a key term in the capital structure. For example, Chen *et al.* (2015a, b) established a simple model to determine the optimal debt ratio and revealed the relationship between debt ratio and hurdle rates of financial indexes of projects. Feng *et al.* (2017) optimized capital structure for PPP projects by applying a genetic algorithm-based model and a case of Beijing No. 4 Metro Line project. How to determine the optimal capital structure of BOT projects under consideration of the influences of internal and external factors? Wang and Jin (2019) solved this problem through building a financial model using an interval number to represent the uncertain factors. The practioners can optimize capital structure by analyzing irregular fluctuation of the unpredictable factors.

3.3.4 Contract management of PPP in the construction industry. There are many uncertainties and conflicts between the public and private sectors due to the complexity and long duration of PPP projects. Thus, contract management is critical to the success of PPP projects. In the past two decades, some attractive issues regarding PPP contract include requirement of flexibility, contract duration and termination, contractual and relational governance elements, renegotiation and dispute resolution.

Through literature review and case study, Demirel *et al.* (2016) discussed the potential changes and subsequent requirements of flexibility in PPP contracts to ensure that the project can proceed according to schedule. Similarly, Cruz and Marques (2013) developed a model of contract flexibility based on dual-input matrix and evaluated the benefits of flexible contract of a case by a model based on real options theory. Odoemena and Horita (2017) investigated the reasons of PPP contract termination from the points of contract, transaction cost and industrial organizational theory. Camilo *et al.* (2018) built a theoretical model based on a survey conducted among PPP practitioners in the Netherlands to explain the mediating role of contractual and relational governance elements in PPP projects.

Not all contingencies can be predicted when enacting the PPP contract. Thus, a renegotiation, which can influence benefits of the public and private sectors, is required. Based on real option value theory, the study of Xiong and Zhao (2016) considered renegotiation as actual options, built a model to examine its value by three steps, and applied the model in a case. Xiong and Zhao (2014) also developed a concession renegotiation model including three compensating approaches. For the dispute resolution, Khanzadi *et al.* (2017) studied the conflicts between the contractor and employer in a delayed Design–Bid–Build projects. Sostak and Vakriniene (2011) adopted a mathematical model of dynamic programming to explain the dispute proceeding between the investors and third parties.

3.3.5 Legal and procurement issues of PPP in the construction industry. Compared with the traditional project procurement approach, PPP is featured with relatively long duration of the relationship and distribution of risks between the public and private sectors. In the past decade, scholars focused on issues regarding procurement of PPP, such as critical factors in PPP briefings, selection of different PPP approaches, procurement views of practitioners, consideration of sustainability, concessionaire selection and concession period issues and government guarantee.

Tang *et al.* (2013) identified four categories of critical factors in briefing phases through literature review and developed a mathematical model to rank factors for improving the briefing phases of PPP projects. Cheung *et al.* (2010) interviewed experienced practitioners of the public sector to determine their views on procurement of PPP projects and compared the views of practitioners in Hong Kong and Australia. Solino and Vassallo (2009a, b) explained the theoretical basis of applying different PPP approaches to urban railway projects and discussed why the Madrid–Barajas international airport case eventually adopted a non-integrated PPP approach. The study of Hueskes *et al.* (2017) encouraged that PPP

procurement should consider sustainability by 25 literature reviews of Flemish PPP infrastructure projects and two case studies.

Selecting appropriate concessionaires and determining concession periods are critical to the success of a PPP project. Applying Monte Carlo simulation to estimate net present value (NPV), Jin *et al.* (2019) proposed concession period determination framework which was verified via a PPP transportation project. Carbonara *et al.* (2014) presented a methodology to decide the concession period, allocating reasonable risk to the public and private sectors to create a win–win solution. Vassallo *et al.* (2012a, b) evaluated the impact of economic recession on the performance of concessionaires and analyzed the effectiveness of measures taken by the government to help concessionaires avoid bankruptcy.

In the process of PPP procurement, governments generally provide restrictive competition, revenue and debt guarantees. Wibowo *et al.* (2012) studied a methodology to quantify guaranteed payments for PPP toll road projects and developed extensive models to estimate risks, including rising land cost, inflation rates and initial flows, to protect the benefit of project sponsors. Buyukyoran and Gundes (2018) developed a real-option-based model to identify the optimum upper and lower boundaries of compound MRGs and maximum revenue cap options. Liu *et al.* (2014a, b, c) discussed the restrictive competition guarantee in PPP projects and developed a model to evaluate restrictive competition on the foundation of real option theory. Based on the Taipei Mass Rapid Transit station experience, Tserng *et al.* (2014) explained the mechanism of structured governmental debt guarantees (GDGs) and then constructed a GDG game model to bridge the theoretical gap.

3.3.6 Governance and performance issues of PPP in the construction industry. PPP has been widely used as an innovative approach but has also encountered many controversies. Hence, performance and governance are of considerable importance to the promotion of PPP projects. Over the past decade, scholars have focused on issues, such as government accountability and stakeholder management, as well as approaches of performance evaluation.

Wu *et al.* (2016) provided a conceptual framework to identify accountabilities of governments in PPP projects and investigated a Chinese PPP project. On the foundation of contractual relationship between government and private investors, Liu *et al.* (2016) constructed principal–agent models to analyze the mechanism of curb opportunistic propensity of private investors. Through a comparative case study of four PPP infrastructure projects, the research of Schepper *et al.* (2014) demonstrated the importance of incorporating stakeholders into PPP projects and suggested using a dynamic dual stakeholder management tool to allocate accountabilities.

Yuan *et al.* (2012) presented an indicator system from the perspective of stakeholders by using a questionnaire survey and examined the hypothetical relations between indicators and operation performance to evaluate the operation performance of PPP projects. Yuan *et al.* (2010) also established a system of 15 performance objectives from the viewpoint of stakeholders and determined the relative importance of these objectives via a questionnaire survey. Love *et al.* (2015) provided an approach to measure life-cycle performance of PPP and suggested proofreading future assets and ensuring value for money through building information modeling.

3.3.7 Literature research of PPP in the construction industry. PPP is a multi-disciplinary research area. Through an objective bibliometric measure, Narbaev *et al.* (2019) revealed relationships between all the disciplines involving PPP. They also stated PPP is a self-contained meta-discipline that dominated by Construction Management and Economics Public Administration and Management and Transportation Research disciplines.

Some researchers aimed to summarize research results and reveal emerging trends. For example, Tang *et al.* (2010) selected six construction journals and pointed out further research: risks, financing, contractual agreements, development of PPP models, concession

periods and strategies in choosing the right type of PPP. Neto *et al.* (2016) analyzed PPP articles published between 1990 and 2014 and indicated contract termination and renegotiation were challenge in PPP management. Zhang *et al.* (2016) conducted a comparative study revealing the findings of PPP publications in Chinese journals and international journals from 2005 to 2014. Cui *et al.* (2018) conducted a systematic research and derived the following six research topic related to infrastructure PPP projects: financial package and PPP application, economic viability and VFM, risk management and success factors, procurement and contract management, performance management and governance and regulation. Based on analysis of PPP articles and proceeding papers from 1996 to 2016, Song *et al.* (2019) identified the intellectual structure and knowledge domains of PPP research and concluded future directions, such as risk allocation, real option-based evaluation.

Besides, there were literature researches of PPP only focusing specific area or issue. Papajohn *et al.* (2011) provided an overview of research on US transportation PPPs in the areas of economics, law and public opinion. Through concept-driven and the Grounded theory methods, Phuong *et al.* (2019) provided comprehensive risk inventory, harmonious language and taxonomy for risk classification. Carmichael *et al.* (2019) analyzed approaches applied in options in PPP toll road projects based on state-of-the-art literature.

3.4 Research methods used in identified articles

Ke *et al.* divided the research methods into topic identification (literature review, post research, industry response and communication), data collection (literature review, case study, interview and questionnaire), knowledge processing (statistical analysis, scenario analysis, simulation and theoretical analysis) and validation process (focus group meeting, pilot study and interview). To present some new knowledge, this study categorized from a different perspective. It investigates the specific research methods adopted by the PPP articles. Based on a careful examination, three research methods (Figure 10) most widely used by the PPP articles were found and discussed next.

3.4.1 Case study. Case study (129) is most popular in identified articles, which was often employed to validate the results or only be illustrated and analyzed. PPP model is sophisticated due to the intricate organizational structure, risk and profit-sharing strategy and financing model. Case study can identify the common or distinct features and various interactive processes of projects and show their effects on the implementation of systems (Tserng *et al.*, 2011). Scholars can also more easily draw some implications from actual cases than that from other research methods. Sobhiyah *et al.* (2009) studied the mechanism of increasing VFM by analyzing the case of Rudeshur gas turbine power station. Chen *et al.* (2012a, b) used the construction industry of Taiwan to analyze relationships among success variables of construction partnering. Hypothetical case was frequently used. Liu *et al.* (2017)

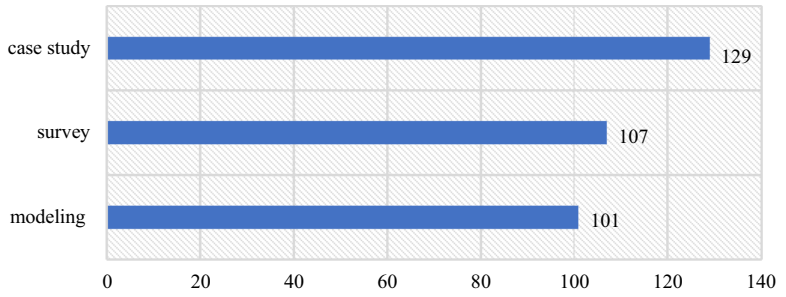

Figure 10.
Number of top three methods used in identified articles

applied a hypothetical case study to demonstrate that flexible-term contracts relatively increase project leverage.

Moreover, multi-case study was frequently employed by researchers to conduct empirical study and draw comprehensive conclusions. Nguyen *et al.* (2018) collected empirical data to identify critical risks and define the risk mitigation strategy in PPP toll road projects in Vietnam. Hande and Zeynep (2018) presented a case of a PPP airport project to identify the effect of stakeholder-associated risks to the success of mega-engineering projects. This finding shows that using specific PPP projects as a case has become increasingly common.

3.4.2 Survey. Survey was employed 107 times in selected articles, which is ranked second place in the research methods used in identified articles. Target respondents are asked to answer standard questions of pre-designed survey instruments (Yuan *et al.*, 2012). Research on factor identification was often implemented via survey. Questionnaire survey and interview are used frequently.

Chan *et al.* (2010) explored the CSFs of PPP projects, which were collected via an empirical survey. Some scholars also used the combination of literature review and survey. For example, Xu *et al.* (2010) utilized literature review and survey to develop a risk allocation model for PPP projects in China. Factor identification was conducted for other topics; for example, risk factors (Shrestha *et al.*, 2018; Alireza *et al.*, 2014) and performance driver factors (Yuan *et al.*, 2010, 2018a, b), which affect the effectiveness and efficiency of analyzing the needs of stakeholders (Tang *et al.*, 2013).

In addition, some scholars examined the relative importance of different factors through surveys. Chan *et al.* (2011) designed an empirical survey to examine the relative importance of different risk factors and analyze the allocation of risk factors to different parties in PPP projects. Cheung *et al.* (2010) used survey to rank the importance of 15 attractive and 13 negative factors for adopting PPP. Researchers generally adopted survey to identify and validate factors for PPP based on the knowledge of experts.

3.4.3 Modeling. The modeling method was used 101 times and ranked third. Modeling is suitable for analyzing inherent mechanisms of particular PPP research themes. Some theories and methods are often used in modeling methods. Among these theories, Monte Carlo (16), Real Option (14) and Game Theory (14) were the three most prevalent modeling development instruments in identified articles. Akcay *et al.* (2017) performed Monte Carlo simulation to estimate NPV of a hydropower investment, which was identified in a hydropower investment case in Turkey. Ashuri *et al.* (2012) used real option analysis to price MRGs and traffic revenue cap options as compound options. Game theory was used to explore the sophisticated decision process or establish interest–optimization models (Tserng *et al.*, 2014).

In addition, researcher also preferred to Fuzzy Theory, Fuzzy Synthetic Evaluation Model, Fuzzy Analytical Hierarchy Process, Analytical Hierarchy Process (14). Ameyaw and Chan (2015) established appropriate risk allocation mechanisms between public and private sectors by using fuzzy set theory. Al-Azemi *et al.* (2014) presented a new evaluation framework, assessing the most common and significant decision factors related to risks in BOT projects based on the analytical hierarchy process model. Ameyaw and Chan (2015) analyzed the characteristics of genuine and spurious PPP projects in China based on the fuzzy analytic hierarchy process.

With regard to determining the quantitative relation of the interdependence of variables, Regression was selected 10 times; Structural Equation Modeling (five) and Social Network Analysis (four) were often employed. Yuan *et al.* (2018a, b) employed structural equation modeling and confirmatory factor analysis to examine relationships among variables, which indicated the pathways to improve the operation performance of public rental housing projects delivery by PPP. Ng *et al.* (2010) also applied structural equation modeling into examining the relationships between evaluation factors and satisfaction of stakeholders. Social Network Analysis is a quantitative analysis method, which is often adopted to analyze

positionality. Zhu *et al.* (2019) used social network analysis to outline the value conflict network and analyze value conflicts between local government and private sector.

In the aspect of financing issue, Transaction Cost Economics (5), Dynamic Capital Structure Approach (2), New Institutional Economics (2), Benefit-Cost Analysis (2) and Break-Even Analysis (2) were employed. Ho *et al.* (2015) developed a transaction cost economics-based theory and analyzed the opportunism-focused transaction cost, which is beneficial to PPP economic feasibility analysis. Tserng *et al.* (2014) also used transaction cost economic theory to analyzed relationship between the hold-up problem for government and designed contractual structure.

In addition, some interdisciplinary methods gained popularity, such as Agent Model (6), Artificial Neural Network (3). For example, agent model was applied in analysis of the risk-sharing ratio most suitable for the government. Wang *et al.* (2018a, b) also introduced the reciprocal preference theory based on the traditional agent model and established set up an optimal incentive mechanism to guarantee the project's income. Artificial neural network models have been widely employed to develop nonlinear data relationships and improve estimates. Shahrara *et al.* (2017) used artificial neural network models to reveal the relationship between the project's important parameters or risk variables.

4. Future research directions

This study has presented a systematic review for PPP research streams. Many researchers have made significant contributions to PPP development. However, some deficiencies still exist in PPP theories and practices in the construction industry. Therefore, some research directions are recommended as follows.

4.1 Area development PPP (ADP) for regional social sustainability

The sustainability of PPP indicates the sustainable implementation of PPP projects and regional social sustainability (Yuan *et al.*, 2019a, b). The PPP Institute of Chinese Academy of Fiscal Sciences (CAFS) innovatively proposed ADP, in which private sectors establish a long-term cooperation relationship with governments, and provide comprehensive development services, such as infrastructure and urban operation, with industrial development services as the core (CAFS, 2019). The ADP promotes regional social sustainability and people-oriented urbanization. The government does not provide any guarantee and relies on newly increased income created by private sectors. For example, an integrated development PPP project in Gu'an high-tech zone, China, was conducted in ADP. This project contributed to the fiscal revenue of the local government, increasing from 110 million yuan in 2002 to 9.85 billion yuan in 2017 (Cheng *et al.*, 2018). However, compared with the traditional PPP model, the private sector undertakes additional management responsibilities and significant risks in ADP. The scope and regulation of ADP also deserve more attention from government and researchers. In addition, the revenue of private sectors depends on the performance appraisal result. Therefore, improving its capability of risk response, especially financial risk, is meaningful for the private sector. By contrast, a strong performance appraisal system deserves additional attention, which is informative for PPP practice in other regions.

4.2 Quantitative risk assessment and risk allocation technique in PPP practice

Risk assessment and allocation are respectively part and parcel of risk management. Many methods were applied in the two processes, such as stochastic revenue projection model (Liu *et al.*, 2017), interpretative structural modeling (ISM) (Iyer and Sagheer, 2010), Bayesian approach (Wang *et al.*, 2018a, b), (FST) (Mazher *et al.*, 2018), bargaining game theory (Li *et al.*, 2017a, b) and artificial neural network (Jin and Zhang., 2011). Nevertheless, most risk assessment and allocation models or techniques proposed in extant research are conceptual

and complex. Understanding these abstract research findings is difficult for practitioners. In addition, the risk transferred from the government to the private sectors may be overvalued in the operation stage (Siemiatycki and Farooqi, 2012). The expected risk transferred to the private sector has never been implemented and the government would finally undertake all risks in some cases (Hodge and Greve, 2007). Systematic risk measurement contributes to the fair allocation of risks, thereby improving efficient risk management in the PPP decision process. Furthermore, quantifying and simplifying the risk management techniques are necessary to assist the practitioners in effectively dealing with risks in PPP practice.

4.3 Systematic market-oriented compensation mechanism for early terminated PPP project

With the development of PPP mode, the quantity of early terminated PPP projects has continued to increase. According to the Private Participation in Infrastructure Database of World Bank (2017), there are 662 early terminations among 16,085 PPP project between 1980 and 2017. The rational compensation between the government and the private sector is a main issue for the early termination of PPP projects. The main causes of early termination in PPP projects were divided into the following: government default or voluntary buyback, private sector default and reasons of non-default (US Treasury, 2017). Some abstract and general compensation models are found from the guidelines, such as "Standardization of PFI Contract" in the UK (HM Treasury, 2007) and the "Commercial Principles for Social Infrastructure" in Australia (Council of Australia Governments, 2008). On this basis, the book value method (estimation of the book value of the project assets based on the unreimbursed investments and default responsibilities) and market value method (assessment of the market value of the remaining concession considering the project's future cash flows) were developed to calculate appropriate amount of compensation (Zhang and Xiong, 2015). However, some factors, such as the liabilities, sums payable to subcontractors and insurance cost, were not discussed in existing compensation models (Song *et al.*, 2018). The static compensation models are inapplicable to PPP practice. Therefore, the future research should comprehensively consider early termination factors and build dynamic market-oriented compensation mechanisms. In addition, establishing a standardized compensation system for different types of PPP projects or regions is necessary.

4.4 Rational and applicable government regulation and supervision mode

With the development of PPP worldwide, government regulation and supervision are urgently necessary (Marques, 2017). Regulatory and supervisory qualities are of considerable importance in the facilitation of private investments and improvement of government capabilities (Sabry, 2015). Nevertheless, due to different goals and asymmetric information between government and private sectors, the performance of government regulation and supervision is poor. The framework of government regulation and supervision mainly incudes market access, service quality and social fairness (Cui *et al.*, 2013). The qualitative methods, such as evolutionary game theory, were mainly applied in government regulation and supervision mode studies, thereby resulting in less objectivity and applicability of the model. For example, through qualitative analysis of the determinants of government supervision modes, the volatility of the supervision modes was rare (Gao and Liu, 2019). Some variables in the model, such as public participation and reputation incentive, were also neglected (Yue and Lin, 2019). In addition, the equilibrium between overregulation and deregulation of governments require increased attention in future research (Koliba *et al.*, 2014; Mouraviev and Kakabadse, 2015).

4.5 Satisfaction management of tripartite stakeholders in different stages and fields

Tripartite stakeholders include the government, private sector and general public. The satisfaction of tripartite stakeholders is reflected by appropriate government support and

adequate and high-quality products or services provided by the private sector (Schepper *et al.*, 2014). The satisfaction of stakeholders is a crucial factor for PPP project success (El-Gohary *et al.*, 2006; Zou *et al.*, 2014). At the tender stage of a PPP project, the government may improve satisfaction by inviting other stakeholders to design the assessment criteria of the bid (Mouraviev and Kakabadse, 2015). Compared with traditional projects, satisfaction management of PPP projects is complicated due to its long construction and operation periods. Therefore, satisfaction life-cycle management of tripartite stakeholders is also significant other than the tender stage. In addition, Yuan *et al.* (2019a, b) established a dynamic price and subsidy adjustment model based on stakeholder satisfaction, which is beneficial for balancing tripartite satisfaction. However, this model is only applicable to transportation PPP projects. Practitioners in different fields also desired a stakeholder satisfaction management model to improve tripartite stakeholder satisfaction. In the future research, stakeholder satisfaction management in different stages and fields requires attention from researchers.

5. Conclusion

Currently, PPP plays an important role in the delivery of products and services in the construction industry. Meanwhile, it attracts some researchers' attention to reviewing PPP practices and exploring valuable strategies for improving implementation. This study conducted a systematic review of the PPP articles published in 12 widely recognized construction journals from 2009 to 2019. It also compares with Ke *et al.* (2009) who reviewed the PPP literature of 1998–2008. The review results showed that the number of PPP articles published in 2009–2019 has substantially increased comparing to 1998–2008 and that the trend of PPP research would continue due to some governments' support after their success in other jurisdictions. Based on the number of articles (PPP) and ratio (>3%), the journals JME, IJPM, JCEM-Construction, JCEM-Civil, CME, ECAM and IJCM were considered active in PPP research. In addition, review results also reported that researches related to PPP in Asia showed the rapid progress from 2009 to 2019 due to the active promotion of PPP in the area. Besides, PPP research in Australia, Portugal, Spain, Iran and Belgium were also steadily growing. PPP research in the UK and USA were less than those two decades ago. The Hong Kong Polytechnic University, Southeast University and Hong Kong University of Science and Technology were identified as the most vigorous institutions in PPP research, owing to their stable, productive research teams. As for the citation, there are significant increases in IJPM, JCEM-Construction, JME, ECAM and CME. Particularly, IJPM has the largest increasing range in the aspect of times cited per PPP article. Albert P. C. Chan (China-HK), Ke Yongjian (Mainland China) and Wang Shouqing (Mainland China) are active researchers in PPP research; Wang Shouqing is also active from 1998 to 2008. This review investigated the research methods used in the identified PPP articles and found that case study, survey and modeling were the most prevalent. Moreover, this review presented five major research streams of PPP in the past decade, which are promotion of PPP, risk management process of PPP, financial issues, contract management, legal and procurement issues, governance and performance issues and the literature research of PPP in the construction industry.

Although the objectives of this study have been achieved, there are limitations. First, the classification of research streams was proposed subjectively and bias might occur because of the authors' limits to knowledge and experience. Second, the literature search was carried out in WOS only and some PPP articles indexed by other databases might be omitted. Lastly, in order to reduce repeatability in citations, the total citation counts mentioned in this paper are based on the search engine (WOS) only. Citations in some other databases like Google Scholar and Scopus were not included. This may omit citation counts of some articles to a certain extent.

Despite these limitations, this study contributes both to the current body of knowledge and to the practice. It identified five future research directions which may answer the following questions. How to define the scope and promulgate proper regulation of ADP? Especially, the risk response and performance appraisal system are important. How to quantify and simplify risk management techniques? How to deal with the systematic market-oriented compensation mechanism for early terminated PPP Project? How to balance the overregulation and deregulation of governments? How to satisfy tripartite stakeholders in different stages and fields? All the questions deserve attention from researchers and practitioners in the future. In addition, the results of this study will allow practitioners to considerably benefit from the research findings of institutions to choose enquiry agencies. Also, it reminds practitioners of complex part, such as risk management process and following proper procedures for PPP applications. In addition, the current findings are informative for researchers to recognize the research gaps and future research directions. Though comparative analysis, both of practioners and researchers can grasp the change of PPP development trend during the past two decades. The number of publications considering PPP demonstrates a growing tendency. The activity of PPP research is related to PPP practice. The future PPP research on underdeveloped area (for example, in Africa) may be vigorous due to the international assistance to infrastructure construction development in recent years.

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