

# Comparative Analysis on the PPP Research in Chinese and International Journals: A Bibliometric Perspective

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**Abstract:** With the widespread application of PPP in the construction field, the research on this topic has attracted considerable attention globally. A critical literature review, with comparison between the results from China and other countries, may facilitate a more comprehensive understanding of the research trend in various contexts. Based on a visual map analysis using the CiteSpace software, a total amount of 2,399 pieces of PPP literature published in Chinese and international journals in 2008-2018 was screened and analyzed, in terms of the yearly number of publication, keyword cluster, keyword citation burst, as well as core institutions and authors. The main findings are: (1) The total amount of PPP literature has been increasing with 33.09% on average in the period investigated. In addition, the Chinese journals produced around 5 times of the publications in comparison to the international journals. (2) The Chinese PPP literature was focused more on the research theme of financing, while the international literature paid more attention to project management related issues. (3) The collaboration between the international PPP research institutions was closer than the Chinese institutions. (4) The authors who contributed most of the Chinese PPP publications are the teams led by Mr. Jia from the Chinese Academy of Financial Sciences, and Professor Chan from the Hong Kong Polytechnic University in international publications. It was also suggested to conduct comparative research with a global perspective on PPP topic and to explore the application of modern technology in PPP projects to improve the management performance.

**Keywords:** CiteSpace; PPP; Visual Map; Chinese; Comparative Analysis

## 1 Introduction

Public-private partnerships (PPP) refers to the benefit-sharing, risk-sharing, and long-term cooperative relationships established between the government and social capital, in order to strengthen the supply of public goods and services with higher efficiency (China National Development and Reform Commission 2014). According to the statistics from the China Public Private Partner Center (CPPPC 2019), a total of 9,299 projects with the investment of RMB 14175.9 billion were included in its project database. In addition, the Chinese government departments/agencies at various levels have issued a series of policies to regulate the development of PPP, such as the Implementation Guidelines on Promoting the Regulative Development of Partnership between the Government and Social Capital, issued by the Ministry of Finance of China on March 11, 2019. With the promotion from the Chinese government and urgent market needs in the construction industry, the PPP model has a broad development prospect in the forthcoming years.

Since PPP can relieve the government of fiscal expenditure burden, improve operation efficiency, and enhance innovation (Christine and Jan 2008; Petersen 2019), its application has been also very popular globally (Almarri 2018). The rapid growth of PPP in China and worldwide, and more importantly, the exchanges and interactions between China and international markets are becoming integrated. It is hence

imperative to investigate the differences and similarities in the understanding of PPPs. In addition, existing research also indicated that PPP research in Mainland China has contributed a significant proportion of PPP knowledge globally (Zhang et al. 2016; Zhang et al. 2020). However, with comparison to the large volume of Chinese PPP publications, only a small amount of PPP research by Chinese community has been published in international journals. This might prevent overseas researchers or practitioners from getting a more comprehensive understanding about the PPP research status in China because of the potential language barrier. Addressing the gap in this field, research in Chinese and international journals was selected as the data to achieve the research purpose. Through a holistic literature review, the research trend and core research institutions/authors in both China and overseas institutions are quantitatively compared, which will enable the academics and practitioners to be well informed about the development of PPP knowledge worldwide.

## 2 Literature Review

There are a variety of PPP models, including BOT, BT, TOT, DBFO and BOOT (Zhang et al. 2016). Although Build-operate-transfer (BOT) and private finance initiative (PFI) are considered as two primary models (Song et al., 2019), the popularity of their application in different economies are different. For instance, in the UK, 91 percent of the total PPP projects were delivered using PFI model. In contrast, BOT is the major model being applied in India and China which was utilized in 47 and 77 percent of all PPP projects (Cheng et al. 2020). Due to its inherent advantage, PPP model has been applied in different types of construction projects, ranging from transportation, water, waste treatment and health care (Zhang et al. 2020). These advantages include risk transfer from the public sector to the private entities, cost savings because of private sector's innovation and efficiency, on-time project delivery with the incentive of early operation to getting revenue by the private entity (Cheung et al. 2010). However, a number of disadvantages in PPP application should not be overlooked. For instance, the risks involved in completing a PPP project are very significant, PPP project delivery arrangements are usually very complex with many parties involved with conflicting interests and objectives, and the PPP tendering process can be lengthy and complicated (Cheung et al. 2010). All these factors may lead to the failure of PPP projects without excellent project management in the application process. With this background, many researchers have studied the critical issues of PPP application, such as financing (Mostafavi et al. 2016; Lu et al. 2019), critical success factors (CSFs) (Chan et al. 2010a; Osei-Kyei and Chan 2017), risk identification and allocation (Yu et al. 2018; Yuan et al. 2018), performance evaluation (Love et al. 2015; Liu et al. 2018; Rohman and Wiguna 2019), legal issue (Muleya et al. 2019) and sustainability (Haavaldsen et al. 2014; Shen et al. 2016). For instance, Osei-Kyei and Chan (2017) compared the similarities and differences of CSFs for PPP project delivery in developing and developed economies/countries. The research results indicate that the importance of sixteen CSFs are different in Ghana and Hong Kong. Zayed and Chang (2002) identified eight primary project risk areas, including political risk, financial risk, revenue and market risk, promotion risk, procurement risk, development risk, construction completion risk, and operation risk. Shen et al. (2016) investigated the influences of the contribution distribution between public and private entities on PPP project sustainability performance. A model with the name of the sustainability performance-based evaluation model (SPbEM) was proposed for the assessment of the level of sustainability performance for PPP projects.

A significant amount of research has been published in recent years on PPP topic. A systematic and comprehensive literature review is helpful to better reveal the knowledge structure and development trends

of PPP research (Song et al. 2019). For example, on basis of a two-stage literature review approach, PPP papers from 1998 to 2008 were analyzed by Ke et al. (2009), in terms of the yearly number of PPP papers published, the authors' contribution, and the research topics in their studies, through content analysis of PPP publications in four international construction journals. Osei-Kyei and Chan (2015) methodically reviewed the CSFs for PPP implementation among some selected top international journals from 1990 to 2013. The two studies were based either on limited volume of research papers on PPP or focused on a particular topic under PPP theme. As a result, the results did not represent the overall PPP research trend across the world. Zhang et al. (2016) selected 685 PPP papers from 2005 to 2014 based on a three-phase literature review framework, and analyzed the main research methods, research topics, and research findings through content analysis and statistical analysis methods. However, this research was conducted five years ago, and a considerable number of PPP papers have been published thereafter. Bao et al. (2018) identified and classified 282 PPP international papers from a life-cycle perspective based on a structured search method and a five-step classification process. However, the literature review results were conducted based on the analysis of a limited number of publications and failed to reflect the overall trend of PPP research trend globally. Most recently, Jayasena et al. (2020) conducted a systematic literature review and analysis on developing PPP models for the delivery of smart infrastructure. The results enabled the identification and categorization of the importance and barriers for developing smart infrastructure in PPP model. However, the findings were investigated in a specific domain of smart infrastructure development. Eshun et al. (2020) conceptualized a win-win scenario in PPP based on a systematic literature review. The research identified a total of 40 constructs and classified them into six components. Similarly, this research was also conducted from a specific perspective in the PPP knowledge area. In contrast, Zhang et al. (2020) conducted a literature review of PPP publications from 2009-2019 screened from the 12 top-tier construction journals. The derived PPP research in these journals were categorized into seven topics. The research status and gaps were drawn and five future directions were proposed. The primary limitation of this research was that it is based on a single database with only 279 pieces of PPP articles being analyzed.

In a bibliometric analysis, the descriptive approach is utilized to derive a general understanding of a topic, with the assistance of specific software (e.g. CiteSpace) for knowledge mapping (Huang et al. 2019). Many Chinese and international researchers have employed this approach to conduct literature review research on the PPP theme. For example, Huang et al. (2018) analyzed 400 PPP papers with high citation record from China National Knowledge Infrastructure (CNKI) from 1997 to 2017, to map the PPP research trends in China. Song et al. (2019) used CiteSpace to perform a cluster analysis on 1,360 PPP papers published in the Web of Science (WoS) from 1996-2016, to depict the knowledge structure and emerging trends of PPP research. However, the above studies only utilize the domestic or overseas PPP papers as the research sample, without comparative analysis on the similarities and differences between Chinese and international PPP research. Globalization is the major and obvious trend of economic development in recent years, hence, global production networking has a significant influence on PPP project delivery (Siemiatycki 2013). As Chen et al. (2020) claimed, the limited understanding on the differences in PPP development in different areas highlights the importance of conducting comparative research. However, existing research on PPP is primarily concentrated on a specific country or sector. This knowledge gap is worth investigation, since a comparative study using samples from two sources will yield more comprehensive literature review results, which is valuable for PPP researchers to embark on more informed research in the future. This paper adopted a similar research framework by Zhang et al. (2016) and conducted a comparative bibliometric analysis between the Chinese and international PPP research with the assistance of CiteSpace software. The research outcome of this paper will be helpful for both

Chinese and overseas PPP researchers to understand the similarities and differences between Chinese and international PPP research achievements and trends, which might benefit them in embarking on future research in this field. In addition, the practitioners worldwide may also have a broad understanding about the development trend of PPP in different economies to enable them to make more informed decision on the investment and management on PPP projects.

### **3 Research Method**

#### **3.1 Research tool**

CiteSpace is an information visualization software developed by Professor Chen from the Drexel University in the United States, which is very strong in conducting literature bibliometric analysis using the data mining algorithms and visualization methods (Chen 2004). Because it can present the structure, regularity and distribution of scientific knowledge through visual means (Li and Chen 2016), the software is often used to analyze the research hotspots, research frontiers and research trends in a specific area, such as Song et al. (2019). CiteSpace V software, with the version of v.5.5 R2 (64-bit), is utilized in this study to analyze the research trends in PPP field and produce visualized results such as node size, network connectivity and co-occurrence of keywords.

#### **3.2 Data selection**

CNKI is a popular database with the largest amount of digital publications in China. Hence, the Chinese PPP literature was collected from CNKI. WoS has excellent compatibility with CiteSpace (Li et al. 2018), and is one of the largest academic publication databases in the world (Jia et al. 2019), which has been widely used as the literature searching source in existing literature review studies (Hosseini et al. 2018). Hence, the selection of international PPP literature in English was derived from WoS. In order to improve the quality of literature samples, the Chinese PPP literature was generated from Science Citation Index (SCI) source journals, Engineering Index (EI) source journals, high-quality journals acknowledged by Peking University Library, Chinese Social Sciences Citation Index (CSSCI) source journals, and Chinese Science Citation Database (CSCD) source journals. The English PPP literature was collected from the WoS core collection. Since PPP includes a variety of models, such as Build-Operate-Transfer (BOT), Build-Own-Operate-Transfer (BOOT), Build-Own-Operate (BOO), Design-Build-Finance-Operate (DBFO), Transfer-Operation-Transfer (TOT) (Ke et al. 2011), all these keywords were used to ensure a complete retrieval of PPP-related journal publications. The specific details used in the search process are shown in Table 1.

< **Insert Table 1 here** >

A three step data collection approach, similar to Zhang et al. (2016), was employed in this study. In the first step, using the search details shown in Table 1, a total of 3,121 and 512 records were generated from the CNKI and WoS core collection database, respectively. In the second step, a further manual screen was implemented to assure the journal papers being relevant with PPP topic through a review of the title and abstract of each paper, which led to 1,957 and 442 valid samples of Chinese and international PPP papers. Since PPP includes many other meanings in different fields, this step is very important to remove irrelevant publications to improve the quality of data analysis results. For example, about 40% of the publications was discarded in this step. In the third step, bibliometric analysis, with the assistance of CiteSpace software,

was conducted to these valid PPP articles to achieve the proposed research objectives (Song et al. 2019), including keyword cluster analysis, keyword citation burst analysis, core research institution analysis and core author analysis.

## 4 Data analysis

### 4.1 Yearly number of PPP publications

The statistical analysis results of the publication time of the Chinese and international PPP papers are shown in Figure 1.

< Insert Figure 1 here >

It can be seen from Figure 1 that the number of Chinese PPP papers fluctuated slightly from 2008 to 2013, as is also the case for international PPP papers from 2008-2018. In 2013, at the Third Plenary Session of 18<sup>th</sup> Central Committee of the Communist Party of China, the Chinese government stated that social capital was encouraged to participate in the investment and operation of urban infrastructure through concession and other means. With this promotion from the central government, PPP has received strong national and local policy support in China (Zhang et al. 2016). This might explain the increasing trend of PPP research papers in China since 2014, with an average annual growth of 55.92% to 2018. During this period, the Chinese journals produced around 5 times of publications in total (1,952) with comparison to international journals (442). Based on the above analysis results, it is argued that the PPP topic is more popular to Chinese researchers than international academics, specifically from 2014-2018. In addition, a considerable amount of PPP journal papers in this period was authored or co-authored by the researchers in China. Further analysis showed that on average the PPP journal publications in Chinese and international journals has been increasing with 33.09% from 2008-2018. Considering the development trend in the latest years, it is likely that PPP will still attract considerable attention from academia in the forthcoming years globally.

### 4.2 PPP research keywords

#### 4.2.1 Keyword cluster analysis results

Using the CiteSpace software, node type was chosen as the keyword and the threshold was set as 20 to generate a knowledge map illustrating the cluster of keywords. The time series diagram of keywords is generated (see Figure 2 and Figure 3), showing the visualization of keyword clusters, change and connection of keywords overtime in Chinese and international PPP publications, respectively.

< Insert Figure 2 here >

< Insert Figure 3 here >

(Note: Research keywords appears sequentially with the time axis. The larger node stands for the higher frequency of research keywords and better centrality. The line between the two nodes indicates that the keywords appeared in the publications simultaneously.)

From Figure 2, it can be seen that 7 clusters of keyword in Chinese papers were produced, i.e. PPP model (*PPP Moshi in Chinese*), project financing (*Xiangmu Rongzi in Chinese*), capital (*Ziben in Chinese*),

public-private cooperation (*Gongsi Hezuo in Chinese*), government and social capital cooperation (*Zhengfu Yu Shehui Ziben Hezuo in Chinese*), finance (*Caizheng Jinrong in Chinese*) and accounting (*Kuaiji Hesuan in Chinese*). Whereas in Figure 3, seven clusters of keywords in English papers were organizational capability, China, fuzzy synthetic evaluation, public-private partnerships, BOT contract, project management, and risk analysis.

#### 4.2.2 Keyword clusters in Chinese PPP papers

Cluster 0 is the *PPP model*, which can be merged with cluster 3 the *public-private cooperation*, and cluster 4 the *government and social capital cooperation*, which have the same meaning in Chinese. The construction of Shenzhen Shajiao B Power Plant in BOT model in 1985 was considered as the first project in China's PPP history. Due to the inherent nature of cooperation, benefit sharing and risk sharing, PPP is widely used in developing China's public services and infrastructure from then on. The interpretation or application model of PPP are different in different countries or at different historical periods. In China, the government emphasized the long-term cooperation between the government and social capital, and intended to improve the supply efficiency of public goods and service through utilizing the strong financing and operating capabilities of private entities (Zheng et al. 2016). MoF (2014) also claimed that the application of PPP model has improved the project performance and extended the public service scope. A variety of PPP models were applied in China. For example, the BT model was employed in Beijing Olympic subway project and Shenzhen No.5 subway project, whereas the BOT model was used in Shenzhen No.4 subway project. Considerable PPP research was focused on summarizing the lessons learned from the application of PPP model in these projects (e.g. Yang et al. 2014).

Cluster 1 is the *project financing*. Attracting sufficient capital investment from private entity is one of the most important features of PPP model. The large capital investment, long concession period and many uncertain factors make PPP projects frequently meet financial bottlenecks. Therefore, in this cluster the Chinese researchers mainly studied the application of financing models, financing risks and financing feasibility. For example, Yuan et al. (2011) established a financing structure optimization model based on Monte Carlo technology, and analyzed the main influencing factors and their functioning mechanism. Xiang and Song (2016) identified financial risk factors from the perspective of financiers, and analyzed the correlation between the various financial risk factors. Additionally, they constructed a causality diagram and a flowchart model of the dynamics of financial risk system. Wang et al. (2018) analyzed and verified the positive impact of financing intensity on the financial risk of PPP projects based on complex system theory and institutional theory. In addition, Hou et al. (2017) argued that asset securitization provided a new path for financing PPP projects and will have a broad application future in PPP area, since it had the advantages of increasing asset liquidity and achieving the objective of risk isolation.

Cluster 2 is the *capital*. Under this theme, the Chinese researchers primarily concentrated on the topics of stakeholder management in PPP from the perspectives of public interest, responsibility allocation between the government and private entity, stakeholders' participation, public responsibility, and role of public and social capital. For example, Liu et al. (2014) selected 18 typical PPP projects and analyzed the asset characteristics and capacity requirements of different types of PPP projects, and summarized the international experience of equity structure and debt-to-equity ratio selection, through investigating the capital structure (only the equity structure and debt-to-equity ratio were considered) of the case projects. The results provided a valuable reference for the arrangement of capital structure of PPP projects in China. Wang et al. (2019) analyzed the allocation of project control rights between the government and social capital using the connotation of control rights and decision-making theory, and identified the influencing

factors of the control rights allocation for PPP projects. The research results showed that the degree of publicity of products and services, level of risk management of project company, and the degree of innovation of project technology were the main factors affecting the allocation of control rights in PPP projects.

Cluster 5 is the *finance*. Compared with the pure public supply mode, the financial risks in PPP model are much higher. The information asymmetry caused by multi-party cooperation, contradiction between profitability-driven nature of social capital and equity of government's endorsement for public services, and opposition between public and private entities in risk sharing might bring potential financial risks to the government. Wen et al. (2015) established a scientific and comprehensive supervision technology and method for PPP project financial risk as well as risk supervision operation process and management system on the basis of lessons learned from international experience, and proposed recommendations on developing policy to strengthen the supervision finance risks in China's PPP projects.

Cluster 6 is the *accounting*. Accounting had a direct influence on determining whether the accounting information of a PPP project met the quality requirements. Qualified accounting information can represent the property value flow of a PPP project and between investment entities, guarantee the safety and integrity of assets invested by the parties and the property rights of the PPP projects, and ensure the realization of public interest (Dong 2014). In addition, the decomposition and reconfiguration of property rights in PPP projects will further complement and improve the accounting theory and methods.

#### 4.2.3 Keyword clusters in international PPP papers

Cluster 0 is the *organizational capability*. PPP projects are usually initiated through solicited or unsolicited proposals. Different processes of proposing models often lead to different levels of government and social capital participation and responsibility. Therefore, organizational capacity is particularly important for both government and social capital (Yun et al. 2015). For example, Jin (2010) identified the main characteristics of transactions related to risk allocation in PPP projects from the resource perspective of organizational capabilities. Huang et al. (2013) concluded that well-organized public entity, appropriate risk allocation and sharing, as well as strong private entity are the most important CSFs for the implementation of PPP projects in Singapore.

Cluster 1 is the *China*. China represents the trend of PPP development in developing countries because of its economic prosperity and huge construction investments in recent years (Cheng et al. 2020). Further analysis indicated that many international PPP research was focused on the study based on Chinese PPP project cases or from a Chinese perspective. For example, Chan et al. (2010a) studied the potential of applying PPP model in China, and conducted a questionnaire survey among Chinese construction professionals, to explore the critical success factors of initiating PPP project in China. Wang and Zhang (2018) used Bayesian analysis method together with expert judgment and historical data, to construct a risk occurrence probability model, which was used to predict the incidence of several key risks of PPP waste incineration projects in China.

Cluster 2 is the *fuzzy synthetic evaluation*. It is a comprehensive evaluation method based on fuzzy mathematics, which is often used for quantitative analysis in PPP projects. For example, Xu et al. (2010) developed a fuzzy synthetic evaluation model to determine the fairness of risk allocation between the government and private entities. Wu et al. (2017) identified 44 risk factors and calculated the probability of occurrence, influence magnetite, comprehensive risk level and total risk using fuzzy synthetic evaluation, to evaluate the risks of straw power PPP project in China.

Cluster 3 is the *public-private partnerships*. As a modern mode of financing and operating infrastructure

project, the PPP concept is accepted and applied by more and more countries in the world, and is considered as originating from the Private Finance Initiative (PFI) mode in the UK. Because the PPP model has been applied in western countries much earlier than in China, the lessons learned from these successful and failed projects provide valuable guidance in the PPP application in China. According to Grimsey and Lewis (2005), achieving improved Value for Money (VfM) or enhanced quality of services with the same investment was of paramount importance to the public sector, which might explain why PPP was a popular model in initiating a project. Almarri and Boussabaine (2017) also argued that VfM was a critical factor for the public sector to choose the PPP model in a specific project, instead of traditional procurement methods. In fact, the experience and expertise of the private entity were utilized to achieve VfM, in terms of higher-level of innovation, efficiency and quality (Osei-Kyei and Chan 2015).

Cluster 4 is the ***BOT contract***. As mentioned earlier, BOT is one of the important models of PPP, and BOT contracts are often used in developing infrastructure projects. In this field, Ashuri et al. (2012) employed real options theory to determine the price minimum revenue guarantee option in BOT projects. Feng et al. (2015) investigated the impact of government guarantee on toll, road quality, and road capacity in BOT highway projects from the perspective of the private sector. Song et al. (2017) established a bargaining game model with complete information to analyze the negotiation process of early termination compensation, and provided a compensation scheme for early termination in BOT highway projects to resolve the problem of incomplete contracts. In fact, in the early PPP research outcomes, Dr Robert Tiong in Singapore leading the research team has contributed lots of efforts on the risk management study of BOT projects in China (Ke et al. 2011).

Cluster 5 is the ***project management***. With comparison traditional projects, the management of a PPP project is much more challenging due to the increased complexity of contract system, a significant number of parties involved and a much longer period of construction and operation duration (Zhang et al. 2016). Several pieces of literature were focused on the research of project management issues in PPP model. For example, Kavishe and Chileshe (2018) employed the theory of innovation diffusion to determine the degree of integration of project management practices and principles during the PPP implementation stage of housing projects in Tanzania. Due to the specific nature of PPP model, a number of critical factors have impact on the successful management of these types of projects. For instance, Love et al. (2015) suggested that the adoption of Building Information Modeling (BIM) can enable key decision-makers to make informed decisions throughout the project life cycle, and hence BIM can be considered as the catalyst for future proofing PPP projects which can achieve the successful management of an asset across its life-cycle.

Cluster 6 is the ***risk analysis***. Similar to the findings of Ke et al. (2009), risk analysis is one of the central research topics in the PPP field. Objective, reliable, and practical risk analysis was critical to the successful implementation of a PPP project (Xu et al. 2010). According to Song (et al. 2019), the risks associated with PPP projects were primarily explored by researchers from two aspects: risk identification and risk allocation. For example, Iyer and Sagheer (2010) identified 17 type of risks in the developmental phase of PPP project from the scenario of road sector in India. Chan et al. (2011) identified and evaluated the main risks of implementing PPP projects in China, and proposed an appropriate risk allocation strategy between the government and social capital. Yuan et al. (2015, 2018) derived six potential dimensions of residual value risk (RVR) factors in the Chinese PPP projects, including poor maintainability, decrease in operation function and poor sustainability. Nguyen et al. (2018) investigated critical risks influencing the financial viability of the Vietnamese PPP toll road projects and categorized them into four primary types: construction cost risk, operation revenue risk, operational and maintenance cost risk, and financing cost risk.



### 4.3 Keyword citation burst

The analysis results of keyword citation burst reveal the frequency of a specific keyword cited in the publications over a certain period of time, and are another valuable reference to understanding the development trend of the research theme (Li and Chen 2016). The analysis of keyword citation burst was conducted in the Chinese and international PPP papers, and the results are shown in Table 2 and Table 3, respectively.

< Insert Table 2 here >

< Insert Table 3 here >

As shown in Table 2, similar to the analysis results of keyword clusters, in the research period, the financing issue was always an attractive topic in China, since five related Chinese keyword bursts were generated in the analysis process. Specifically, internet finance was the latest research topic in Chinese PPP papers. Wu and Wang (2017) argued that the Private to Government (P2G) platform can use the internet technology to make the government service and product supply free of geographical and time constraints, and also provide a new way to relieve the local government of financing burden. If the topics of investment and VfM were also included in the financing research field, it is argued that the researchers in China paid more attention to the research of PPP economic issues during this period. In 2011, the Chinese government stated that social capital was encouraged to enter into the affordable housing construction (MOHUD 2011), which might explain the high citation level (8.6011) of this keyword in 2012-2014.

While in Table 3, the international researchers were more focused on the PPP project management related issues, such as the early procurement and risk management, optimization and project management, followed by contracting and concession model. As stated by Chan et al. (2010b), PPP procurement was considered an effective way to achieve VfM in providing public infrastructure or services. However, in order to achieve the success of a PPP project, the various stakeholders should pay special attention to these project management issues. Additionally, in recent years, research on the lessons learned in successful and failed PPP projects was very attractive in international PPP papers. For example, Wang and Ke (2018) summarized lessons learned in a vehicle charging infrastructure in Anqing, China, and proposed relevant suggestions for implementing similar projects in the future.

### 4.4 Core research institutions

Using CiteSpace software, the institution was chosen as the node type and the threshold was set to top 20, to generate a knowledge map showing the contribution of PPP by different institutions. The cluster analysis results of core institutions in Chinese and international PPP papers are shown in Figure 4 and Figure 5, respectively.

< Insert Figure 4 here >

< Insert Figure 5 here >

As shown in Figure 4, the core research institutions contributing most of the Chinese PPP papers in descending order are the Chinese Academy of Financial Sciences (*Zhongguo Caizheng Kexue Yanjiuyuan in Chinese*), the Institute of Financial Science of the Ministry of Finance (*Caizhengbu Caizheng Kexue Yanjiuyuan in Chinese*), Tianjin University of Technology (*Tianjing Ligong Daxue in Chinese*), Tianjin

University (*Tianjing Daxue in Chinese*), and Chongqing University (*Chongqing Daxue in Chinese*). The findings also indicated that the research collaboration between these institutions was not strong, although considerable Chinese PPP papers were published in the period.

It can be seen from Figure 5 that, the core research institutions contributing most of the English PPP papers in descending order are the Hong Kong Polytechnic University, the University of Maryland, the Hong Kong University of Science and Technology, Tsinghua University, and Southeast University. With comparison to the status in Chinese PPP publications, the research collaboration between these institutions was much stronger in producing international PPP research papers.

#### **4.5 Core authors**

Employing CiteSpace software, the author was chosen as the node type and the threshold was set to top 20, to produce a knowledge map showing the contribution of PPP research by different authors. The cluster analysis results of core authors in Chinese and international PPP papers are shown in Figure 6 and Figure 7, respectively.

< **Insert Figure 6 here** >

< **Insert Figure 7 here** >

As illustrated in Figure 6, the core authors publishing most of the Chinese PPP papers in descending order are Mr. Jia from the Chinese Academy of Financial Science, Professor Yuan from the Southeast University, Professor Ye from the Chongqing University and Professor Wang from the Tsinghua University. The figure also indicates that the collaboration of these researchers was strong in their institution and was weak with researchers from other institutions. While as shown in Figure 6, Professor Chan from the Hong Kong Polytechnic University and Professor Skibniewski from the University of Maryland contributed most of the PPP publications. These researchers had more strong research collaborations within and outside of their own institutions.

### **5 Conclusion**

A considerable amount of PPP papers have been published in both Chinese and international journals in recent years, with the strong promotion from the government to use this model achieving a higher level of project performance and at the same time relieving the serious financial burden in developed and developing countries. Previous literature review papers on PPP topic were focused either on the analysis of international journals or Chinese journals independently. A comparative analysis on the most recent publications with a significant amount of PPP publications from a bibliometric perspective is identified as an existing knowledge gap in this field. This is worth investigation as the findings will be valuable for PPP researchers globally to understand more comprehensively the research trend in the past, and to embark on relevant research in the future.

With the assistance of CiteSpace software, a bibliometric analysis on PPP research published in Chinese and international journals from 2008-2018 was conducted, in terms of the number of publications on yearly basis, keyword cluster, keyword citation burst, core research institutions and authors with the most significant contributions. Following a two-step robust research process, a total of 1,957 and 442 valid PPP journal papers were identified in Chinese and international journals for further analysis, respectively. It was found that the total amount of Chinese and overseas PPP publications was increasing with 33.09% on

average in 2008-2018. It is likely that PPP will still be an attractive topic in the forthcoming years based on the development trend in the latest 5 years. The analysis results of the keyword cluster and citation burst indicated that the Chinese PPP papers were more focused on the investigation of the financing related issues of PPP, while the international journal papers concentrated more on the project management related issues. In addition, the core institutions and authors in both Chinese and international PPP papers were identified. The results also showed that collaboration between researchers authoring the Chinese PPP papers outside their own institutions was less common, with comparison to authors of the international PPP papers. It is therefore suggested to consolidate the research collaborations in the PPP field for the Chinese researchers. Furthermore, with comparison to the significant amount of PPP publications, comparative research from a global perspective accounts for only a small proportion, specifically in terms of best practices of PPP application in different regions/economies/countries, in different sectors such as transportation/water/waster treatment/power, and in different projects using different types of PPP models (e.g. BOT, BT, PFI, etc.). A typical example is Cheng et al. (2020), whose study comparatively analyzed the policy, development process, contract type, sector distribution and investment scale of PPP model in China, India and the UK. Considering the tremendous risks related with PPP projects, these research will enrich the PPP research community and practitioners at large with a broader understanding about the CSFs of PPP application in different scenarios. More importantly, the research findings will be valuable for policymakers to tailor-make more suitable laws and regulations governing the PPP implementation process, to achieve the success of PPP projects. Last but not least, with the fast development of modern technology in the construction industry, exploring its application in PPP project to enhance the performance would be an interesting topic in the future. For instance, Yuan et al. (2019) presented an experimental system which is verified that the application of BIM and other information technologies can improve the performance of PPP projects.

Several limitations exist in this study which also become possible future research directions in this field. First, in order to ensure the high-quality level of Chinese PPP literature, only the papers published in those first-tier journals (SCI source journals, EI source journals, journals acknowledged by Peking University library, CSSCI source journals, and CSCD source journals) were included for further analysis. Similarly, the PPP papers published in the WoS core collection were included in this study. In this case, some high-quality PPP papers might be overlooked as valid samples. Second, using the keyword as the parameter of analyzing the research trend might also generate incomplete results, since more valuable information contained in a specific research paper can only be identified through in-depth investigation on its abstract, discussions and conclusions. Third, the CiteSpace software is robust in producing objective analysis results with a significant amount of input data. These results shall be supplementary with subjective data analysis to improve the comprehensiveness of the research findings. However, only limited pieces of literature were reviewed in the study during the research process, and as a result, some critical research findings in those papers were neglected.

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**Table 1 Summary of search details**

Data Sources	Period	Search parameter	Search method	Sample size
SCI source journals, EI source journals, high quality journals acknowledged by Beida library, CSSCI source journals, CSCD source journals			Search on the subjects of "PPP", "BOT", "PFI", "BOOT", "BOO", "DBFO", "BT", "TOT", "ROT", "BTO", "BOS", "BLT"	3,121
WoS core collection	January 1 2008- December 31 2018	Advanced Search	TS=(PPP AND public AND private AND partnership OR BOT AND build AND operate AND transfer OR PFI AND private AND finance AND initiative OR BOOT AND build AND operate AND own AND transfer OR BOO AND build AND own AND operate OR DBFO AND design AND build AND finance AND operate OR BT AND build AND transfer OR TOT AND transfer AND operate AND transfer OR ROT AND renovate AND operate AND transfer OR BTO AND build AND transfer AND operate OR BOS AND build AND own AND sell OR BLT AND build AND lease AND transfer)	512

Note: the search was conducted on November 19, 2019.



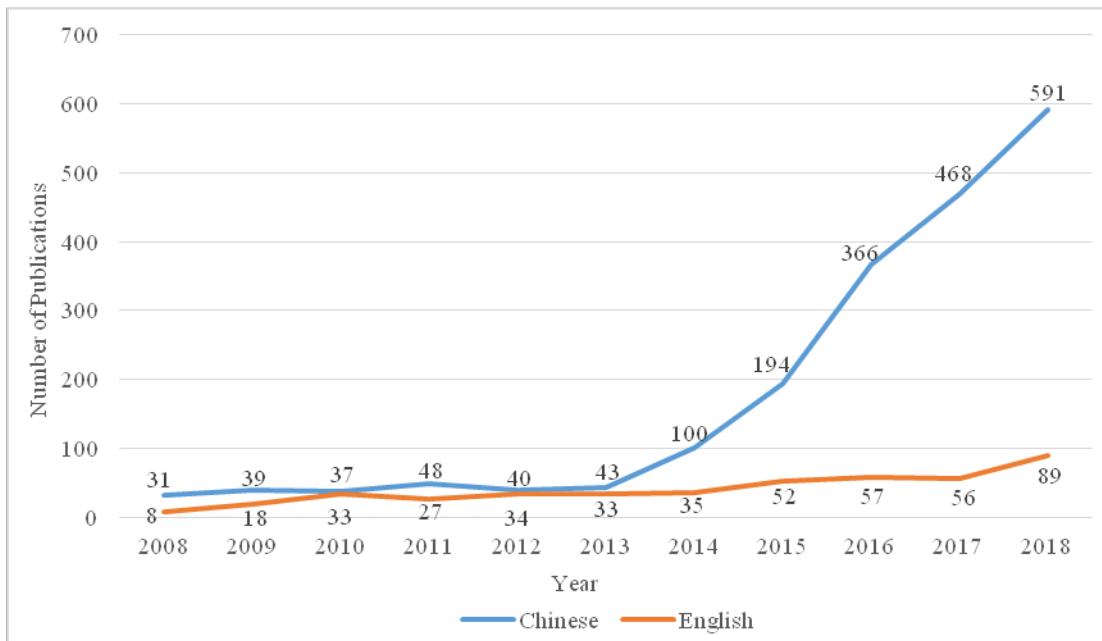


Figure 1 Number of PPP Chinese and international journal papers from 2008-2018

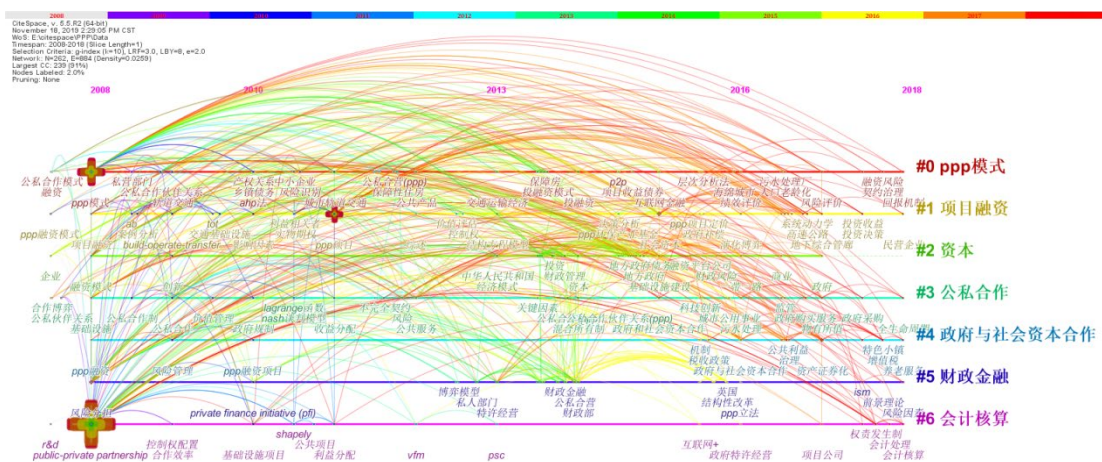


Figure 2 Sequence diagram of keyword cluster analysis (Chinese PPP papers)

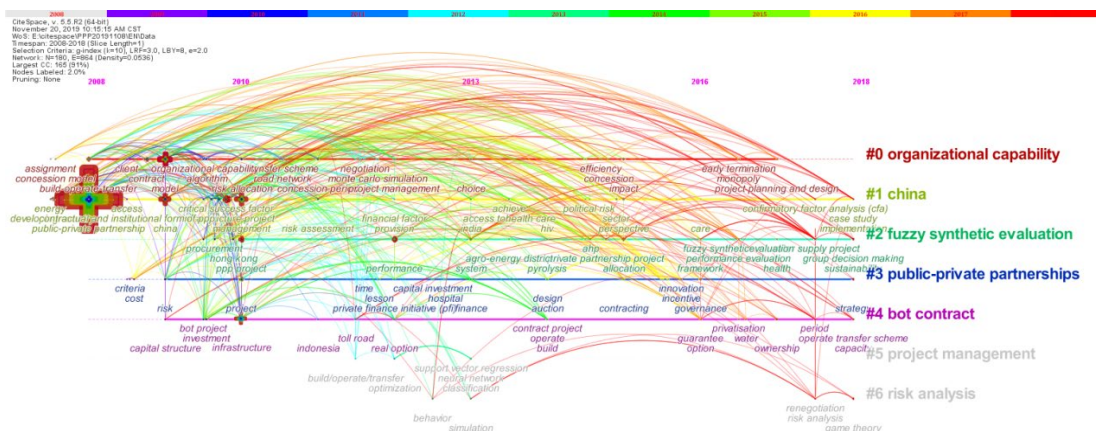


Figure 3 Sequence diagram of keyword cluster analysis (international PPP papers)

**Table 2 Keywords citation burst analysis in Chinese PPP papers**

Keywords	Strength	Begin	End	2008 - 2018
Infrastructure ( <i>Jichu Sheshi in Chinese</i> )	5.1874	2008	2009	
Financing ( <i>Rongzi in Chinese</i> )	4.5115	2008	2014	
Public-private partnerships ( <i>Gongsi Huoban Guanxi in Chinese</i> )	11.8752	2008	2010	
Purchasing power evaluation ( <i>Goumaili Pingjia in Chinese</i> )	2.9138	2008	2012	
Risk management ( <i>Fengxian Guanli in Chinese</i> )	3.183	2009	2010	
Public-private partnerships regulation ( <i>Gongsi Hezuo Zhi in Chinese</i> )	4.2925	2009	2010	
Infrastructure project ( <i>Jichu Sheshi Xiangmu in Chinese</i> )	2.2446	2010	2014	
Affordable housing ( <i>Baozhangxing Zhufang in Chinese</i> )	8.6011	2012	2014	
VfM ( <i>Wuyou Suozhi in Chinese</i> )	1.8048	2012	2013	
Project financing ( <i>Xiangmu Rongzi in Chinese</i> )	3.5792	2012	2013	
Public-private partnerships ( <i>Gongsi Hezuohuoban Guanxi in Chinese</i> )	11.1822	2012	2014	
Incomplete contract ( <i>Buwanquan Qiyue in Chinese</i> )	5.4643	2012	2013	
Private sector ( <i>Sirenbumen in Chinese</i> )	5.5923	2013	2014	
New type of urbanization ( <i>Xinxing Chengzhenhua in Chinese</i> )	5.0943	2014	2015	
Finance management ( <i>Caizheng Guanli in Chinese</i> )	4.2227	2014	2016	
Finance ( <i>Caizheng in Chinese</i> )	4.0784	2014	2016	
Investment ( <i>Touzi in Chinese</i> )	5.0265	2014	2016	
Finance	5.7836	2014	2015	

<i>(Caizheng Jinrong in Chinese)</i>				
Internet finance <i>(HulianwangJinrong in Chinese)</i>	2.2094	2015	2016	
Enterprise management <i>(Qiyeguanli in Chinese)</i>	3.0964	2015	2016	

Note: (1) The keywords of citation burst in Chinese PPP papers are in the brackets. (2) In some cases, different Chinese keywords may have the same meaning in English. Hence, these Chinese keywords were translated into same English keyword. (3) The strength indicates the citation ratio of a specific keyword.

**Table 3 Keywords citation burst analysis in international PPP Papers**

Keywords	Strength	Begin	End	2008 - 2018
Procurement	5.1902	2010	2011	
Risk management	5.3193	2010	2012	
Construction	2.8819	2010	2011	
Partnership	5.2745	2011	2014	
Private sector	3.9885	2012	2015	
Private Finance Initiative (PFI)	3.4382	2012	2013	
Optimization	3.2478	2012	2013	
Road-project	5.7037	2012	2013	
Project management	3.4026	2012	2014	
Finance	4.2848	2013	2014	
System	2.3975	2014	2016	
BOT project	2.9223	2014	2015	
Contracting	3.2124	2015	2018	
Concession model	2.0446	2016	2018	
Lesson	2.2039	2016	2018	

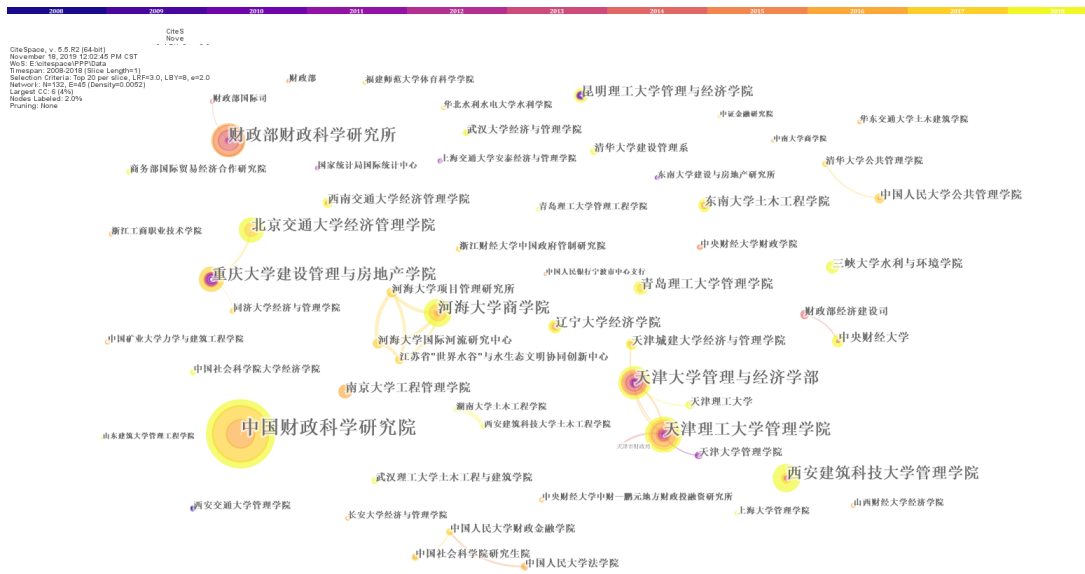


Figure 4 Cluster analysis of core institutions in Chinese PPP papers

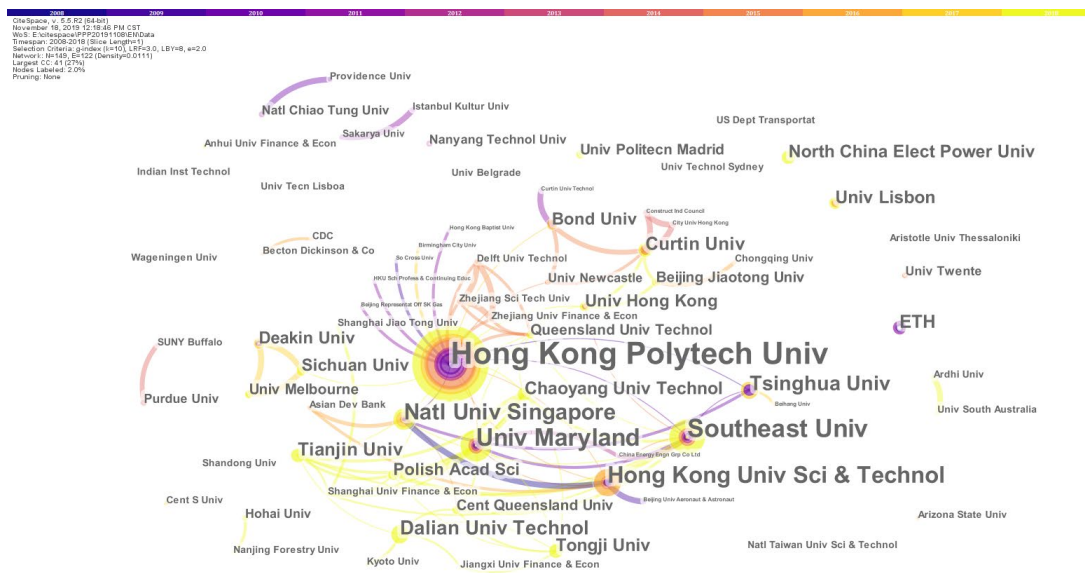


Figure 5 Cluster analysis of core institutions in international PPP papers

