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## Review of Public–Private Partnership Literature from a Project Lifecycle Perspective

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### Abstract

The process of developing a public-private partnership (PPP) is complex and dynamic throughout the project's life cycle of project identification, preparation, procurement, implementation, transfer, and post-transfer phases. Although interests in reviewing general trends and diverse topics of the PPP literature have increased over the years, there is a lack of a systematic review of the PPP literature from the perspective of project life cycle. The purpose of this study is to analyze the research status and possible future studies from the viewpoint of project life cycle. The review is conducted by searching related papers from seven leading construction management journals, then classifying them into distinct phases to facilitate further discussion on significant research topics. The findings show that different PPP phases encounter different problems, attracting uneven attention from researchers. Specifically, the transfer phase, which is the end of PPP contract life cycle and the starting point of post-transfer operation, requires systematic research in the future. The outcomes of this study reveal the relationship between important project problems and corresponding PPP phases, which may serve as valuable reference for PPP participants to develop effective project management strategies, and for PPP researchers to better understand PPP research

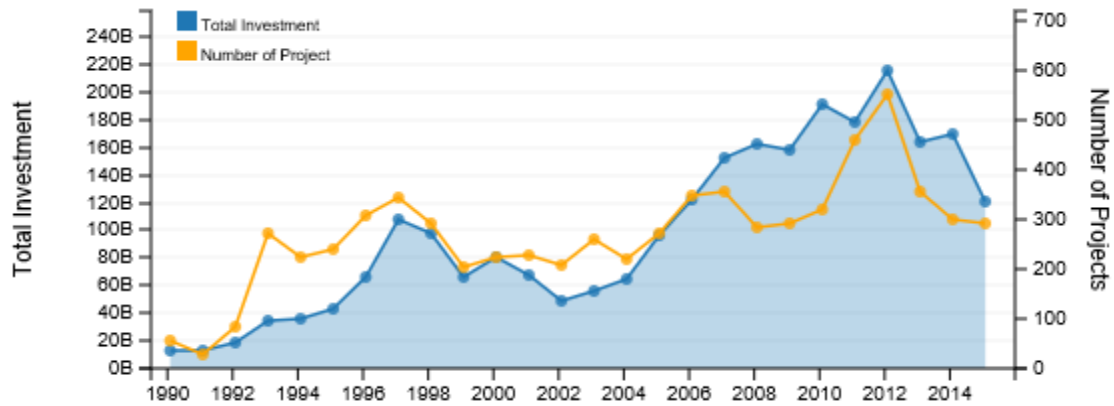
with specific focus on varied PPP phases.

**Keywords** Public-private partnership; Project life cycle; Phases; Transfer; Literature review.

## **Introduction**

Public-private partnership (PPP) has been utilized widely for the development of infrastructure projects around the world due to its effectiveness in delivering value-for-money (VFM) (Chan et al. 2010) which is defined as “the optimum combination of whole life costs and quality” (HM Treasury 2004). This research defines PPP as a long period agreement between a private sector (typically a consortium) and a government body to provide public assets or services, in which the private sector is responsible for dealing with significant risks and management duty and the payment is related to performance (World Bank 2014). In a typical PPP contract, the private sector has to design, finance, construct, and manage the infrastructure component, afford services (World Bank 2014), and transfer assets to the host government when the concession period expires (Yuan et al. 2015).

Fig. 1 shows the trend of PPP project implementation from 1990 to 2014. An increasing trend can be observed within this period (i.e., 1990 to 2014), which peaked in 2012 followed by an unexpected decline from 2012 to 2014. However, a more rapid growth can be expected over time due to enormous infrastructure demands worldwide. According to the World Bank (2017), billions of people worldwide still lack access to clean water, electricity, and all-weather roads. To address this important issue, the Global Infrastructure Facility (GIF), a cooperation among major multilateral development banks, private investors, and governments, was founded in 2014 to provide an open platform with integrated resources for developing complex international infrastructure PPP projects (World Bank 2017).



**Fig. 1.** Investment and number of PPP infrastructure projects during 1990-2014 (Source: World Bank, Retrieved 21 July 2016)

The PPP life cycle has been demonstrated complex and filled with pitfalls (Chan et al. 2005). To facilitate the success of the growing PPP infrastructure development, researchers should continue to observe PPP life cycle, identify potential issues, and provide solutions. Literature review is an efficient and effective means to identify knowledge gaps and provide insights into future research directions. Many researchers have utilized this method to investigate the length of progress in PPP area. For example, Ke et al. (2009) analyzed annual number of paper published, contribution of main researchers and several research interests over 1998 to 2008. Tang et al. (2010) reviewed 85 PPP-related papers from empirical and non-empirical research perspectives. Zhang et al. (2016) conducted a comparative study between the PPP research in international journals and Chinese journals. However, most literature reviews focused on general trends and scattered topics related to PPP, less literature review from PPP infrastructure project life cycle (PIPLC) perspective is available. The efficiency of life cycle perspective in reducing holistic cost of construction projects has been testified for decades of years (Guo et al. 2010). Life cycle philosophy is particularly crucial for PPP projects due to the integrated duties on design, finance, construction

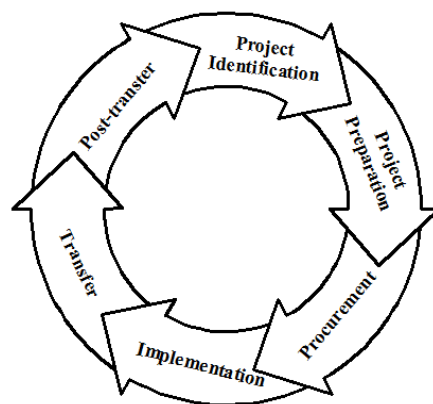
and maintenance [European Investment Bank (EIB) 2012]. Essentially, VFM is recognized as the paramount objective of PPP, which cannot be defined, let alone to be achieved, without a life cycle perspective (HM Treasury 2004). Therefore, a systematic literature review from the life cycle perspective is necessary to provide a better understanding of the state-of-the-art PPP research and in turn, to facilitate improving life cycle management. With the stipulated justifications, this study extensively reviews the papers published by seven top-tier construction management journals from 1996 to 2016. This study is expected to help PPP participants figure out what important problems should be concerned in different phases to facilitate consideration of effective management strategies in advance. Researchers can also be benefited by better understanding of existing research and recommendation of important knowledge gaps from a project life cycle perspective.

### **Life cycle phases in the PPP infrastructure project**

Project Management Institute (PMI) (2013) defines a project life cycle as the series of sequential phases through which a project is developed from its origination to its closure. In spite of the impossibility of distinguishing every type of project life cycle, extracting generic characteristics can benefit the establishment of a basic framework for project management. The names and numbers of the project life cycle phases depend on many aspects, including how the project is managed, what the project is for, what sectors are involved, and what traits the project has. The life cycle of a construction project is normally divided into four phases, namely, conceptual (feasibility), design, construction, and operation phases (Zou et al. 2007).

PPP infrastructure projects, such as water sectors, power plants, highways, bridges, and rail lines, are generally large-scale projects with ongoing maintenance requirements (PricewaterhouseCoopers 2010). Owing to the complexity of PPP arrangement, plenty of governments and organizations [e.g., World Bank, Asian Development Bank (ADB), Department

of Infrastructure and Regional Development (DIRD) of Australia, and EIB] have developed procedure guidelines for evolving and maintaining PPP projects. Summarizing those generic guidelines, a detailed phase division includes project identification, project preparation, competition, preferred bidder phase, contract signing, design, construction, operation, and transfer phase (ADB 2008; DIRD 2015; World Bank 2014). EIB (2012) suggests a clear and concise four-phase division for PIPLC, in which competition, preferred bidder phase, and contract signing are merged as procurement. Then, design, construction, operation, and transfer phases are defined as project implementation. Ministry of Finance (MOF) (2014) of China promotes these four phases by highlighting transfer as a separate phase requiring more effort from public clients. By contrast, other phases (i.e., design, construction, and operation) are mainly the responsibility of the concessionaire contractor (World Bank 2014). Furthermore, the transferred back infrastructure is expected to continue to serve the public, which can be viewed as the post-transfer phase. Therefore, for clear and complete literature analysis, this study divides PIPLC into six phases (see Fig. 2), namely, project identification, project preparation, procurement, implementation, transfer and post-transfer phase.



**Fig. 2.** Phases of PIPLC [Adapted from EIB (2012); MOF (2014)]

## **Research Methodology**

PPP-related literature published from 1996 to 2016 was obtained via an approach used by previous researchers (Darko and Chan 2016; Ke et al. 2009; Yi and Chan 2014). The reason for the specified year period is that PPP started expanding considerably worldwide since 1996 (World Bank 2010). This study began with the selection of a suitable search engine (Scopus) and keywords, followed by the selection of journals and papers, the classification of papers into PIPLC phases, then a critical analysis of the papers from the life cycle perspective. The various stages of the research methodology are explained in detail in the following sub-sections.

### ***Selection of search engine and keywords***

Scopus search engine was used to search for the relevant papers for this study. Scopus was widely used to conduct similar reviews on a variety of topics in literature. This powerful search engine, for example, has been adopted by Ke et al. (2009); Hong and Chan (2014); Yi and Chan (2014); Darko and Chan (2016) and many others to conduct thorough reviews in varying construction management fields.

PPP is a terminology that describes a wide range of contract types (World Bank 2014). In a particular country or jurisdiction, different nomenclature is used to define specific PPP contract types. Therefore, a comprehensive search code is necessary to ensure that relevant types of PPP contracts are not missed. Considering new development in PPP practice [e.g., the UK has promoted PFI (Private Finance Initiative) to PF2 (Private Finance 2)], this study added “*private participation infrastructure*” and “*private finance 2*” and their acronyms to keywords widely used by previous researchers.

### ***Selection of journals and papers***

The initial search identified more than 8000 papers published in over 160 different academic

journals. In spite of search restrictions, many journals focusing on unrelated domain appeared (e.g., Nursing, Medicine and Applied Economics). Therefore, it is necessary to emphasize that the current research was limited to PPP studies in construction management journals. That is, journals that do not concentrate in construction management were excluded. Due to the numerous number of papers that were retrieved from the search, a set of criteria was stipulated to trim the number of papers needed for further analysis. As a result, the journals selected in this research project had to meet either of the criteria below:

1. The journal contains a significant number of papers in the initial search. Hong et al. (2012) set the benchmark in their review on partnering research as exceeding 1% of the total papers. To minimize the possibility of excluding relative papers, the present study adopted 0.25% of the total papers as the benchmark.
2. The journal was ranked within the top six in the quality rating conducted by Chau (1997). Chau's ranking was used because it is widely accepted by researchers in the construction management domain.

Either one or two of these criteria are normally used in most construction management review research (Darko and Chan 2016; Hong et al. 2012). Finally, ASCE's Journal of Construction Engineering and Management (JCEM), Construction Management and Economics (CME), International Journal of Project Management (IJPM), and ASCE's Journal of Management in Engineering (JME) were selected based on the above criteria. Engineering, Construction and Architectural, Proceedings of Institution of Civil Engineers—Civil Engineering (PICE-CE), Engineering Construction and Architectural Management (ECAM) were selected based on criterion 2, and Journal of Infrastructure Systems (JIS) was selected based on criterion 1.

Of the initial numerous papers identified, the seven selected journals captured 325; however,

a few unrelated papers still appeared; as they met some of the search keywords. Also, since this study paid attention to “PPP infrastructure project”, most of the retrieved papers that did not satisfy this criterion had to be discarded. Therefore, the authors scanned all the papers by reading the titles and abstracts, and, if necessary, the main parts, to filter out irrelevant papers. After filtering, 282 papers were valid for further analysis. Table 1 shows the number of papers in selected journals from 1996 to 2016. During the last two decades, JCEM has published the most papers in PPP (78), followed by IJPM (67), then CME (52), JME (41), JIS (21), ECAM (18), and PICE-CE (5). These numerous papers exhibited the long-term popularity of the PPP subject in the past two decades.

**Table 1.** Number of Papers in Selected Journals from 1996 to 2016

Journal Title	Number of Papers
Journal of Construction Engineering and Management	78
International Journal of Project Management	67
Construction Management and Economics	52
Journal of Management in Engineering	41
Journal of Infrastructure Systems	21
Engineering Construction and Architectural Management	18
Proceedings of Institution of Civil Engineers: Civil Engineering	5
Total	282

### *Classification of papers*

As stated previously, the life cycle perspective is of great importance for achieving VFM through PPP. This study, therefore, analyzed literature identified from the life cycle perspective. To conduct the analysis, the foremost step is to classify the papers into fit PIPLC phases. The classification was performed by the research team, following a five-step systematic procedure designed for minimizing subjectivity:

1. Refined the detailed PIPLC phase information based on widely used PPP guidelines such as EIB (2012) and World Bank (2014). These guidelines provide reliable definitions of PIPLC phases and



explicit description of the detailed tasks in each phase;

2. Identified the topic of a paper as precisely as possible to ease designating a paper into proper PIPLC phase;

3. Matched the detailed phase information with the precise topic information. A paper was classified into one phase if clear and direct relation between them had been identified;

4. Merged similar precisely defined topics into main topics at each phase to facilitate a systematic and accessible discussion on literature; and

5. Repeated the above steps until no more changes to the result could be found. For instance, EIB (2012) suggests that, at the project identification phase, risks that originate from the project should be identified, analyzed and allocated. Meanwhile, the present study has recognized a few papers focusing on risk identification, risk analysis and risk allocation. Based on the particular phase requirement, the papers focusing on the three abovementioned topics were classified into the project identification phase. In addition, risk allocation mainly consists three steps, that is, identifying risk, analyzing risk and allocating risk (EIB 2012). Consequently, the three topics (i.e., risk identification, risk analysis and risk allocation) were merged into one main topic – risk allocation.

Following these steps, a total of 16 main topics including a series of subtopics were identified and distributed into suitable phases. The subjectivity and uncertainty of the classification were further minimized as the research was conducted by the same group of researchers (Hong et al. 2012). In this manner, most of the papers can be classified into corresponding phases. However, the research team found that some papers cannot be classified into certain phases as their topics refer to the entire PIPLC, or the relation between the topic and certain phase is not sufficiently evident for proper classification. For example, topic *application introduction* referring to the

research that introduces how PPP is applied and what lessons and experiences can be drawn in particular countries, always covered the entire PIPLC. Therefore, it is inappropriate to categorize application introduction into any single phase. Hence, topics like *application introduction* were defined as indivisible topics that cannot be divided by phases due to their coverage of the whole PPP life cycle. In the following sections, a complete topic list and the number of papers for each phase are presented, followed by a detailed literature analysis and future study recommendation.

### **Literature analysis from life cycle perspective**

#### ***Overview of literature***

Fig. 3 summarizes the complete distribution of the existing PPP research and future studies. Six research categories (i.e., research into five PIPLC phases and the indivisible topics) are presented from the left to the right, with the number of papers under the name of each category. The existing research, located in the upper half of the figure, covers the entire PIPLC. However, a distinct distribution in each phase can be observed. Likewise, the distribution of future studies, which are shown in the lower half, is also uneven. Among the five phases, the project preparation phase has the most papers, mainly focusing on management structure and detailed PPP design, followed by the implementation phase with papers concerning diversity of issues such as risk management, stakeholder management, implementation performance and dealing with changes. Papers at the procurement phase studied bidding process and bidders' concerns, while risk allocation and project selection were discussed by papers at the project identification phase. A significant number of papers shed light on indivisible topics such as application introduction, success, investment environment, failure and other topics. Only three papers were identified at the transfer phase referring to residual risk and review of transferred project. In contrast, the future studies for each phase seem less uneven except for the transfer stage, where a considerable number of future

research agendas have been suggested.

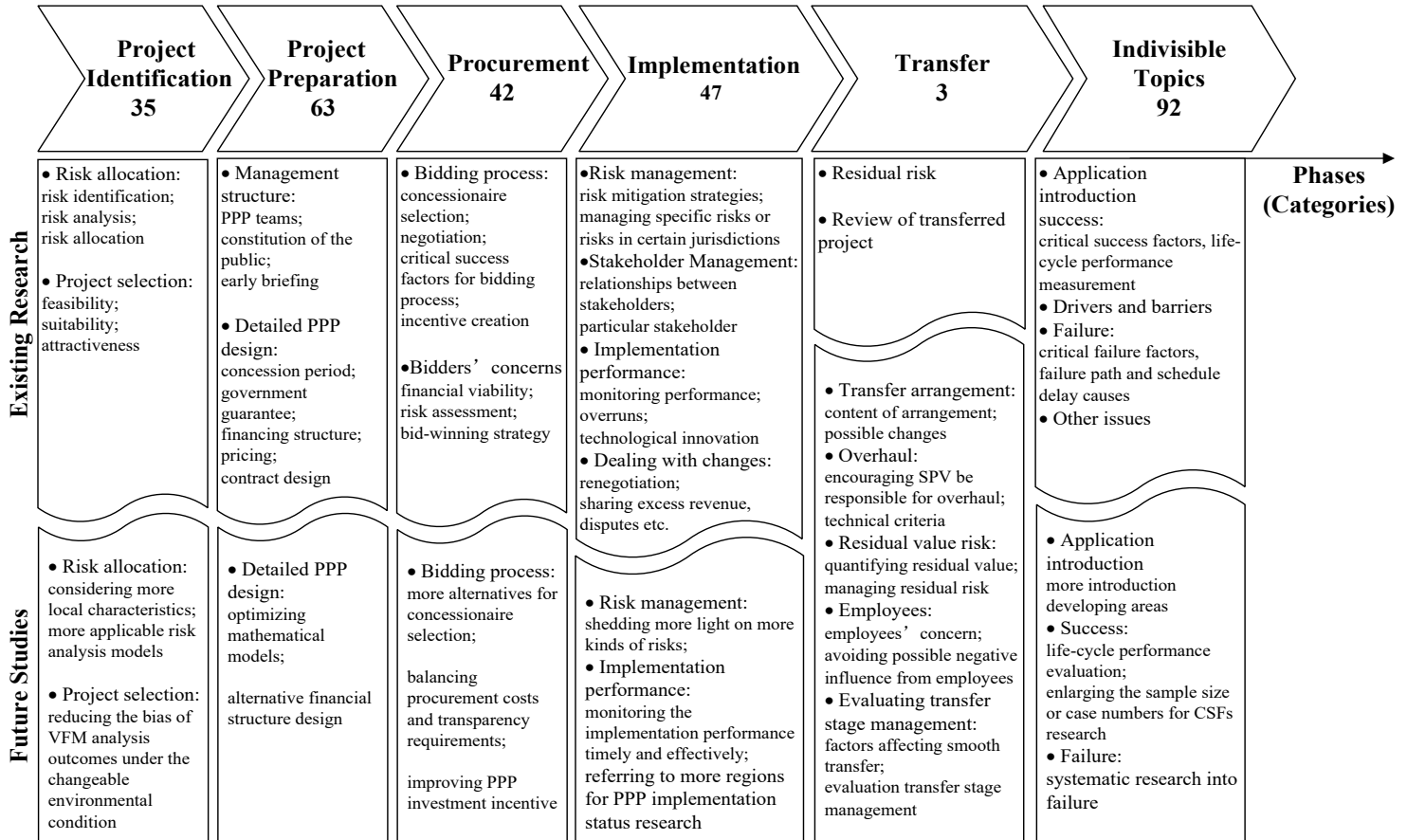
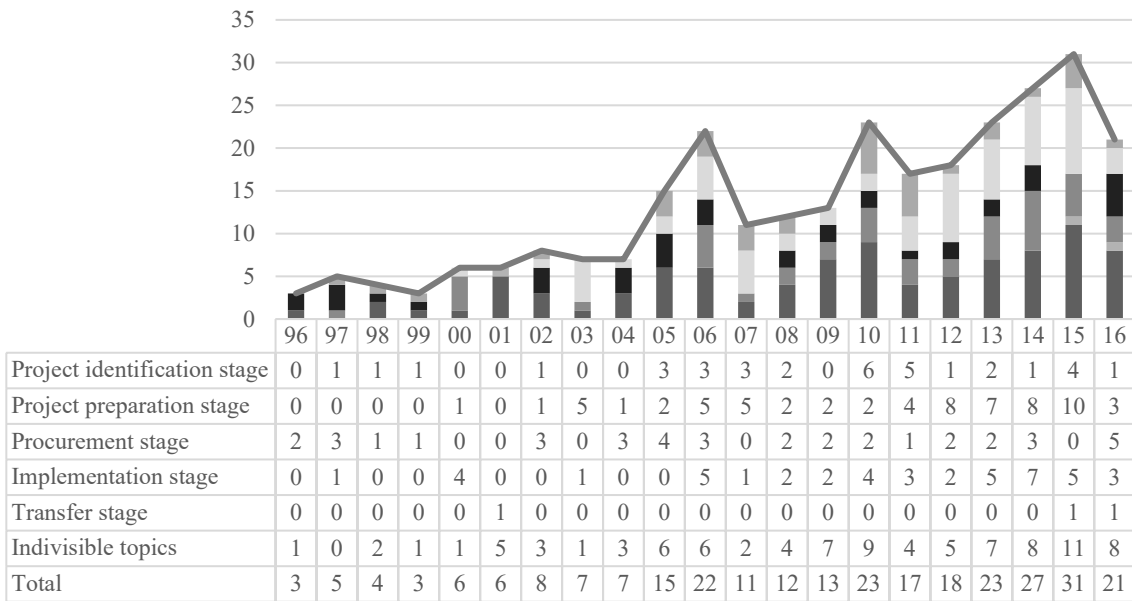


Fig. 3. Complete distribution of existing research and future studies

Within the studied period, a growing trend of PPP papers can be observed with the highest number of publications in recent years (i.e., 2014 and 15) (see Fig. 4). The total number of publications shows that PPP research soared to double digit since 2005 before which relatively less attention was paid to this domain. However, throughout the past two decades, the publication of PPP papers has never been interrupted, which, again, reflects the continuous appeal of PPP research area. More specifically, considering the five phases, researchers seemed more caring about the procurement phase in the initial years. It is understandable given that PPP was still in its exploratory phase then and thus procuring PPP agreements successfully was the primary task.

Afterwards, papers in other phases rose gradually, which may reflect that researchers began to realize that other phases also matter in terms of PPP success. Recently, the project preparation and the implementation phase have attracted relatively more attention from researchers, which may show the difficulty in conducting detailed preparation and long-term implementation of PPP projects. It is also noticeable that studies referring to the transfer phase are rather rare, with only three publications throughout the period in question.



**Fig. 4.** Annual number of papers for each phase (category)

### *The project identification phase*

The analysis of literature shows that, at the project identification phase, risk allocation has been studied the most over the past two decades. Up to 24 papers focused on this topic, taking up 69 per cent of the total 35 papers. The rest papers at this phase studied issues referring to project selection process.

As risk comes from the complex nature of PPP (Grimsey and Lewis 2002), project risks should be identified, analyzed, and allocated adequately to justify the PPP option. Empirical research

methods such as questionnaire survey, case study and experts interview have been used by researchers to develop risk allocation preference. For instance, Li et al. (2005) claimed that risks, such as nationalization and land acquisition, should be retained in the public sector, although majority of risks should be borne by the private. Ng and Loosemore (2007) emphasized the consideration of participant capability, resources, and knowledge to manage risks effectively. The analysis of other relevant papers shows that different industries or jurisdictions prefer different risk allocation schemes [e.g., (Ameyaw and Chan 2016; Jin 2010)]. Therefore, appropriate risk allocation is a cumbersome task in PPP development (Medda 2007). To improve the objectivity of decision making, prior researchers have also offered various decision means relying on mathematic methods such as game theory, fuzzy set theories and artificial neural networks (Jin 2010; Medda 2007).

Project selection is another key process at this phase, through which the projects with the most possibility to achieve VFM are highlighted. The feasibility, which refers to various factors concerning social, political, environmental, legal and financial aspects (Salman et al. 2007), should be justified before employing PPP form to a project. Research into feasibility mainly focused on designing evaluation models/frameworks that can consider the multiple factors as well as stakeholders holistically (Abdel Aziz and Russell 2006; Ashley et al. 1998). VFM analysis is widely used for measuring feasibility. The result of VFM analysis can be gained by a complicated calculating process; however, biased result tends to appear if important parameters (e.g., discount rate) and assumptions are not set properly (Cruz and Marques 2014). Researchers also stressed the attractiveness as well as suitability of PPP, reminding participants that PPP should not be seen as a panacea for the development of all infrastructures (Soomro and Zhang 2016).

### ***The project preparation phase***

The project preparation phase is a necessary, resource-intensive undertaking, which deals with all prerequisites before formally starting a PPP (EIB 2012). Among the five contractual phases, the project preparation phase possessed the most papers (66), partly showing the complexity of managing this phase. Within this phase, the majority (up to 90 per cent) of previous research focused on issues about the detailed PPP design, in which concession period, government guarantee and financing structure were discussed extensively. Relatively less attention has been paid to management structure issues.

The concession period is an important component of the detailed PPP design, which is a measure for determining when the project should be transferred back to the public sector, and differentiates the responsibilities and benefits between public and private sectors (Shen et al. 2002). As a result, the private sector expects the concession period to be as long as possible, which is contrary to the expectation of the public client. Prior researchers explored numerous mathematical and empirical models to support the concession period decision, such as game theory model, Monte Carlo model and stochastic revenue and cost model etc. (Hanaoka and Palapus 2012; Ng et al. 2007). However, Zhang (2009) pointed out that determining the concession period should be based on the win-win principle instead of the traditional means in which a fixed duration is solely provided by the government. Recent research has improved those models, taking into account more factors such as the perception of the publics and the social welfare (Song et al. 2015). Government guarantee, too, has been discussed in plenty of previous research. Although potential cost increase to the public sector may occur, analysis of the existing research shows that most of researchers suggest the provision of appropriate guarantee in PPP arrangement due to its effectiveness in encouraging private investments. All kinds of guarantees have been studied, such as minimum revenue guarantee, minimum traffic guarantee, maximum interest rate guarantee, debt guarantee,

tariff guarantee, restrictive competition guarantee and so on. To set the level of guarantee, some researchers suggested real option-based models and testified them via Monte Carlo simulation, and obviously, the guarantees should be controlled to a proper level, and the best is the minimum level (Ashuri et al. 2012). Cheah and Liu (2006) suggested that the provision of government guarantees needs more consideration concerning their real worth.

For financing structure, most previous research shed light on how to determine an appropriate mix of equity and debt. A high proportion of debt tends to be more welcome in PPP due to its increased cash flows, but low equity financing may increase project profit risks (Schaufelberger and Wipadapisut 2003). Distinct models have been proposed to facilitate the decision making of financing structure [e.g., (Bakatjan et al. 2003)]. The pricing-related literature presents various methods to build reasonable pricing models/mechanisms for PPP services or products to balance the different interests of the public and private sectors [e.g. (Cheng and Tiong 2005; Xu et al. 2012)]. Researchers reached the consensus that PPP allows private investors to seek reasonable profits when producing social welfare via the PPP project (Subprasom and Chen 2007). Research into contract design focused on dealing with uncertainties during detailed PPP design by designing proper contract structure. For instance, Cruz and Marques (2013) claimed that a flexible contract design can increase the value of project in changing conditions. A few previous research has also investigated issues about management structure that relates to tasks to make PPP preparation organized (EIB 2012). For example, research into PPP teams discussed the roles of multiple teams with respect to PPP, including project teams, advisory teams, PPP Task Forces, and PPP units [e.g., (Tserng et al. 2012)].

### ***The procurement phase***

At the procurement phase of PIPLC, an interesting finding is that the prior researchers paid almost

the same attention to both participants of the procuring activity. 22 papers focused on the issues in bidding process (e.g., concessionaire selection, negotiation and incentive creation) concerned by the public client, while the remaining 20 papers concerned the bidders' interests such as financial viability, project risk assessment and bid-winning strategy.

The bidding process consists of a series of steps through which the concession can be awarded to the concessionaire selected. The concessionaire is significant for PPP success because it assumes far more responsibilities and risks than a mere contractor (Zhang 2004). Therefore, it is understood that most of the research into bidding process focused on concessionaire selection. Zhang (2004) claimed that the key to appropriately select concessionaire is to guarantee the high quality of evaluation criteria and methods for evaluating candidates. Zhang (2005) reviewed the literature on evaluation criteria of concessionaire and identified evaluation packages, which consisted of financial, technical, health, safety, and environmental and managerial dimensions. Succeeding researchers continued to improve the criteria definition and the ways to measure proposals, aiming to find robust methods for concessionaire selection (El-Mashaleh and Minchin 2014). The second focus of bidding process is negotiation, which commonly occurs after the selection of the preferred bidder and is about PPP contract details. This negotiation process is always time- and cost-consuming due to conflicting benefits pursued by public and private sector. To better understand what is important in negotiation, researchers identified attributes that impact the contract process from both sectors, such as organizational capabilities for the public sector and high quality of technical proposals for the private sector (Ahadzi and Bowles 2004). Furthermore, contractual negotiation models based on different methods (e.g., real option and Monte Carlo method) were developed to improve negotiation efficiency (Liou and Huang 2008; Liou et al. 2011). Several researchers have identified the critical success factors of bidding process, such as robust business



case, quality of project brief and the capability of public sector etc. (Liu et al. 2016). Some researchers focused on improving incentive creation to attract more potential bidders, as a good procurement of PPP is expected to be competitive. From their investigations, several strategies, such as bid compensation, may work under certain conditions (Ho and Hsu 2014).

On the other hand, bidders' concerns have also been considered by researchers. Based on the analysis of literature, the first concern of bidders is the financial viability of PPP projects. It is understandable because, as mentioned previously, the private sector should be allowed to gain reasonable profit by PPP. Unfortunately, the financial viability is always uncertain due to the nature of PPP infrastructure projects, that is, large size, long contractual period, nonrecourse financing, and distinct motivations (Zhang 2005). Previous researchers therefore have made numerous attempts to evaluate financial viability accurately. For example, Ho and Liu (2002) presented an option pricing-based model that can overcome the shortages of traditional net present value method; Jeong et al. (2016) integrated discounted cash flow analysis, real option valuation and expanded net present value, coming up with a more comprehensive model for financial viability evaluation. Moreover, researchers suggested that the private sector should conduct thorough risk assessment before bidding. To conduct such an assessment, a prototype evaluation model has been introduced, by which bidders can calculate the risk index and rank projects to spot the least risky one (Zayed and Chang 2002). Previous research also suggested some bid-winning strategies for the bidders, such as expressing financial commitments, employing systematic decision models and adopting suitable financing strategy (Tiong and Alum 1997).

### ***The implementation phase***

The implementation phase covers a long period from financial close to the end of the contractual time, normally more than 10 years, filled with complexities and uncertainties (Grimsey and Lewis

2002). Four aspects have drawn much attention from researchers: risk management, stakeholder management, implementation performance and dealing with changes. As shown in Fig. 3, this phase contains a number of subtopics, showing the difficulty in managing PPP contract for such a long time.

Unlike the risk research at other phases that focused on evaluation and allocation of all possible risks, how to manage particular risk or risks in particular jurisdiction became the core at the implementation phase. In other words, mitigations for risks have been emphasized by many researchers. To name a few, Wang et al. (2000) conducted international questionnaire survey and summarized effective mitigating measures for a bunch of political risks in different infrastructure sectors; Boeing Singh and Kalidindi (2006) proposed Annuity-based PPP model to mitigate the traffic revenue risk existing in Indian road projects; Loosemore and Cheung (2015) emphasized the system thinking can be potential solution to risk problems. Previous research has shown much care on mitigating risks in emerging economies (e.g., India and China), which can be seen as a reminder for both authorities and foreign investors to be aware of risk management in places with growing PPP implementation environment.

Stakeholders can be defined as any individual or organization involved in a PPP project with lawful benefit. Much previous research has emphasized that stakeholder involvement is of great significance in achieving PPP success (De Schepper et al. 2014; El-Gohary et al. 2006). Researchers observed many issues such as credibility gap and unreasonable responsibility allocation between stakeholders, and proposed possible solutions to tackle those issues. For example, to facilitate the communication of stakeholders with multidisciplinary background, El-Gohary et al. (2006) presented a sematic model and taxonomy that contain multidiscipline knowledge. Some research also focused on better understanding of particular stakeholders. For

instance, Wu et al. (2016) emphasized that the role of the government should be clearly defined, otherwise the partnership will not work.

In order to guarantee the VFM, implementation performance should be monitored by the public client over the implementation phase. Raisbeck et al. (2010) claimed that, in Australia, PPP projects have better implementation performance than traditional delivery projects. However, low level of performance in the implementation phase has also been observed by previous research, showing the diversity of PPP performance and space for performance increase (Robinson and Scott 2009). Particularly, overruns have been investigated by researchers who found that PPP does not necessarily mean saving time and cost simultaneously (Rajan et al. 2014). Raisbeck and Tang (2013) claimed that PPP does not automatically result in technological innovation, either. Dealing with changes is inevitable in view of the long term of project operation. Some changes are so disadvantageous that should be avoided to the greatest extent. For instance, renegotiation is undoubtedly unwelcome at the implementation phase given that critical changes are not allowed by the concession agreement (EIB 2012). To minimize the negative influence when renegotiation occurs, researchers have proposed decision models like game theory model (Ho 2006; Javed et al. 2014), while others have attempted to uncover key determinants and explain why renegotiation happens easily in particular areas (Cruz and Marques 2013). Previous research also studied positive changes. Excess revenue from successful implementation, for example, has been discussed and the sharing strategy has been proposed (Wang and Liu 2015).

### ***The transfer phase***

Ideally, the transfer process should be clearly defined in the concession agreement. However, either practical experience or existing guideline in managing the transfer phase is relatively limited (World Bank 2014). In current study, only two topics with three papers have been identified at the

transfer phase. Based on review of residual risk (or residual value risk) research, Yuan et al. (2015) identified six critical factors leading to residual risk and proposed a conceptual model to facilitate residual risk management. Yuan et al. (2016) continued to validate this model through two practical projects, and further identified the cumulative effects of residual value. Abdul-Aziz (2001) reviewed a water PPP project in Malaysia which has been transferred back to the government, drawing salutary lessons for future PPP arrangement.

Given that most PPP projects are at phases before transfer (Yuan et al. 2015), a little attention has been paid to this phase. However, long-term vision on the PPP projects is essential for pursuing public benefits because the transfer phase eventually transpires (Yuan et al. 2015). Hence, this phase needs to be further investigated to guarantee successful transfer of PPP projects, and finally, to render infrastructures sustainable in providing public services post-transfer.

### ***The indivisible topics***

Despite the considerable paper number, the research on the indivisible topics is rather concentrated: 47 papers, more than half of the total 92, focused on application introduction. The remaining half analyzed success, failure, drivers and barriers and other issues related to the entire PIPLC. Numerous research relating to indivisible topics may imply that system thinking is significant for PPP development (Loosemore and Cheung 2015).

Research on application introduction mainly introduced PPP application in various jurisdictions. This topic has been studied by the most papers identified in current study. This finding confirms the claim of Zhang et al. (2016) who also found that the PPP application had received the most attention from both Chinese and international journals. In this research, of those jurisdictions studied, the top five most-mentioned are China, the United Kingdom, Australia, Hong Kong, and the United States (Table 2). These places have been highlighted by previous literature

reviews on PPP research (Ke et al. 2009; Osei-Kyei and Chan 2015). China, which was identified by this paper as the most frequently studied country, has witnessed a long period of PPP application practice since the first attempt of Shenzhen Shajiao B power plant (Cheng et al. 2016). Nevertheless, an unstable trend can be observed during the past three decades, and the performances of the existing projects are controversial (Chen 2009; Cheng et al. 2016; Smith et al. 2004). Researchers believe that the future of PPP in China is promising, whereas some unique risks should be noticed due to the special administrative system of China (Zhang and Kumaraswamy 2001). Compared with China, the other four most-mentioned regions are all developed economies. These developed places are relatively experienced in applying PPP. Hence previous research made efforts to summarize their valuable experience to facilitate the PPP development in places where relevant expertise and experience are still inadequate [e.g., (Carrillo et al. 2008; Jefferies and McGeorge 2009)].

**Table 2.** Top 5 most-mentioned countries/jurisdictions in application introduction research

Countries/Jurisdictions	Mentioned times
China	12
United Kingdom	5
Australia	4
Hong Kong	4
United States	3

Previous research also discussed the success of PPP. In particular, critical success factors (CSFs) have been investigated by a number of researchers who identified those factors mainly by questionnaire survey or case study [e.g. (Chan et al. 2010; Li et al. 2005; Zhang 2005; Zou et al. 2014)]. The specific CSFs differ from jurisdictions or sectors. In the UK, for example, the top three critical factors identified through questionnaire survey are strong and good private consortium, appropriate risk allocation and available financial market (Li et al. 2005); while in Australia, a case

study showed that approval and negotiation process, clear project brief and client outcomes, and increased competition during the tendering process were the most critical (Jefferies 2006). Another important aspect for the research on success is the life-cycle performance. The life-cycle performance of a PPP should be arranged in advance and conducted as soon as possible after transfer phase (MOF 2014). To date, research showed that the measurement criteria of PPP performance has already moved beyond the so-called iron triangle criteria (i.e., time, cost, and quality), and the integrated measurement methods that can combine iron triangle, life-cycle and stakeholder perspectives are critical [e.g. (Liu et al. 2016; Yuan et al. 2009)].

Drivers and barriers of applying PPP, which are often analyzed simultaneously, are essential for fostering a mature PPP market [e.g. (Chen and Doloï 2008; Chou and Pramudawardhani 2015; Yuan et al. 2012)]. Similar to CSFs, the drivers/barriers were commonly identified by empirical studies and the specific factors vary from regions. In the US, for instance, the first reason for most companies reject PPP is the availability of adequate funds; in Nigeria, the first barrier goes to capacity deficiencies of the public and private sectors (Algarni et al. 2007; Babatunde et al. 2015). Several recent research has investigated failure since numerous PPP projects have failed to meet the VFM goal as expected. Motivated by these cases, Soomro and Zhang (2015) investigated the responsibilities of the private and public sectors for PPP failure, and mapped the failure path. Critical failure factors in low-cost housing program in Thailand, such as policy pressure, poor bidding documents and inappropriate contractors etc., have also been discussed by researchers (Trangkanont and Charoenngam 2014).

## **Future studies from life cycle perspective**

### ***The project identification phase***

Allocating risks of a PPP project appropriately remains an issue needs more research. Previous

researchers have identified a variety of risks for their own research areas based on a series of risk factors originating from countries with mature PPP system, such as the U.K. and Australia (Li et al. 2005; Ng and Loosemore 2007). Note PPP practice varies significantly from different jurisdictions (Chan et al. 2011); therefore, for developing countries, different risk factors and risk allocation strategies in PPP may have not been revealed sufficiently. Hence, future researchers are recommended to consider more about the local characteristics when conducting risk allocation. Besides, more applicable risk analysis models are still needed. Previous research has attempted to improve the objectivity and accuracy of risk analysis models via complex means (e.g., fuzzy theory and game theory) (Li and Zou 2011; Medda 2007). However, their real popularization may be limited by the necessary knowledge requirement for the practitioners to use them. In addition, feasibility research can be improved by figuring out how to reduce the bias of VFM analysis outcomes under the changeable environmental condition. Demonstrating VFM is always difficult for the government agency that is relatively inexperienced in contrast with the large consortia (Holmes et al. 2006). In this case, it is crucial for researchers to help the government agency choose or estimate key parameters (e.g., discount rate and traffic volume) wisely when conducting VFM analysis.

### ***The project preparation phase***

For research on the project preparation phase, the first possible improvement relates to the further optimization of mathematical models, which are frequently regarded by different items of detailed PPP design, e.g., concession period and government guarantee. Take concession period as an example. Carbonara et al. (2014) summarized three aspects from which concession period models are constructed, namely, concession period calculation, uncertainties and risk factors, and satisfied parties. Their study attempted to integrate three aspects into their model; however, the

effectiveness of the model should be testified and compared to other models with resembling function. Usually, the problem for models is not the shortage in number but to demonstrate the effectiveness alleged (Yi and Chan 2014). The second possible improvement goes to the financial structure research. Previous research has discussed various ways to set optimal debt and equity arrangement; however, only a little research has analyzed how to design optional financial structure if both debt and equity are not adequate (Regan et al. 2013). Considering the growing number of PPP projects, this situation should be concerned more before any real problem occurs. Therefore, future researchers are recommended to find more optional finance mechanisms apart from the traditional finance mechanism.

### ***The procurement phase***

Existing research has shown a variety of methods and criteria to select concessionaire. Typically, the final awarded one tends to be business companies with solid financial or technical ground. However, it is possible for other kinds of organizations to play the role of concessionaire efficiently. For instance, Chen et al. (2006) analyzed the possibility and benefit for a nonprofit organization (NPO) engaging in a PPP. The present research therefore recommends the future researchers to seek more choices for selecting concessionaire, which may be particularly beneficial to places with immature capital markets. What is more, few researchers considered a pair of natural contradiction existing in the procurement process. On the one hand, EIB (2012) highlights transparency and fairness as two key good procurement principles through bidding procedure. These two principles require a competitive bidding process (World Bank 2014), which means more time and cost consumed. On the other hand, public sectors like to minimize transaction costs that are borne by themselves (Carbonara et al. 2016). Therefore, balancing procurement costs and transparency requirements is necessary and needs to be examined. Besides, as mentioned in the introduction



section, an increasing demand for infrastructure is expected globally; however, global economic recession has been observed for years and is believed to continue. Consequently, research into incentive creation could be strengthened to appeal to more PPP investment under the frustrating economic situation.

### ***The implementation phase***

As previously mentioned, research into risk management has attempted to investigate particular risks in detail. The analysis of literature shows that a few risks, such as revenue risk and foreign exchange risk, received relatively more attention. Note that dozens of risks could be identified in a typical PPP infrastructure project due to the complexity nature. As a result, the current study recommends the future researchers to shed more light on more kinds of risks. This will be meaningful and beneficial given that the different risk preferences differ from jurisdictions (Ke et al. 2010). Moreover, implementation performance remains a future research agenda. The first promotion could be gained in monitoring implementation performance for which the government should be responsible (EIB 2012). Previous research has examined the performance for many projects mainly by ex-post evaluation; nevertheless, little has been known on how to monitor the implementation performance timely during the implementation phase. In addition, more research is expected worldwide to map a full scenario of PPP implementation status. The geographic scope of the current research is still not sufficiently wide regarding the vast areas PPP covers, e.g., to the authors' knowledge, less has been known about the PPP implementation in Latin America or Africa.

### ***The transfer phase***

Although very few previous studies were identified, the current research claims that the transfer phase of PPP is worth more future studies. Based on observation on real cases as well as in-depth analysis on literature, the authors found that transfer phase is also filled with uncertainties and

risks. Without proper management, transfer process may be disturbed, and more severely, the sustainability of the public service provision may be not ensured. In combination with the main tasks of the transfer phase (EIB 2012; MOF 2014), some possible research agendas are discussed as follows:

- After the transfer preparation, a detailed transfer arrangement is expected to be determined. As mentioned previously, both guidelines and practical experiences on developing transfer arrangements are lacking (World Bank 2014). Even if a detailed transfer arrangement is accomplished initially, ensuring that all details are still appropriate or acceptable after 10 to 30 years is difficult (Cruz and Marques 2013). Therefore, the following questions should be answered:
  1. What should be defined in advance about transfer arrangement?
  2. What changes may occur when a PPP project is under the transfer phase?
  3. How to deal with those changes for a smooth transfer?
- Overhaul of the main facilities and equipment is usually conducted by the private sector. However, the private sector often lacks incentive to do so due to its high cost (Xu et al. 2012). Besides, overhaul cannot be managed without acceptable technical criteria for transfer. Yet, current technical criteria of PPP seem mainly for maintenance other than transfer. Hence, at least two questions about overhaul require answers:
  1. How to monitor and encourage the private sector to fulfill its overhaul responsibility?
  2. What special technical criteria for transfer should be followed?
- Despite the fact that some research into residual risk has been done, little has been known on how to manage this risk. Furthermore, it is acknowledged that the residual assets can be divided into tangible and intangible assets (Yuan et al. 2015); however, how to quantify them is still

unknown. Hence, for residual risk, the following questions should be solved:

1. How to calculate the value of residual assets, especially the intangible assets?
  2. How to manage residual risk?
- At the transfer phase, the posts of some employees may be threatened by the project transaction. This may impact the interests of the employees and lead to unstable working atmosphere. However, little research has concerned this issue during the transfer phase. Therefore, questions relating to employees may include:
    1. How to protect the employees' interests during the transfer phase?
    2. How to avoid possible negative results related to worried employees during the transfer phase?
  - The legal finalization of the transfer procedure does not necessarily spell the success of the transfer phase management as success has various definitions from different perspectives (Sanvido et al. 1992). Hence, the performance evaluation of the transfer phase management is also essential once a PPP project has been transferred back to the government. The following questions can be examined:
    1. What are the criteria and performance indicators for a successful transfer phase management?
    2. How to evaluate the performance of transfer phase management?

### ***The indivisible topics***

In spite of the considerable existing research, a couple of studies are recommended by the present research. First, more application introductions from all over the world, especially from developing areas, are beneficial to present the full picture of PPP application status. Table 2 shows that lessons and experiences from developing places are still fewer, which does not match the tremendous market capacity of those places. Second, as an increasing number of projects have been/will go into the latter half of the PIPLC, research into success, particularly into life-cycle performance

evaluation, remains a focus. The accurate evaluation of the life-cycle performance will be a difficult task considering the long period and complexity of PPP. For research into success, the CSFs research could also be extended. Previous research has acquired CSFs by limited samples or cases. To make the CSFs more representative, enlarging the sample size or case numbers may help. What is more, a detailed examination of failure is of great benefit as failure can result in huge waste of social resources. Although a few research has been recently carried out, future researchers can continue to focus on failure in a more systematic way.

## **Conclusions**

To facilitate better development of PPP, this study has provided a systematic literature review of the state-of-the-art PPP research published in seven selected journals, namely, JCEM, CME, IJPM, JME, PICE-CE, ECAM, and JIS, from 1996 to 2016.

Based on a structured search method and a five-step classification process, a total of 282 papers were identified and classified from the life cycle perspective. Analysis showed that existing research has covered all the concession life cycle, whereas the distribution of papers differed from phases. The project preparation phase includes the most papers, while the implementation phase consists of the most research topics. The highlighting of these two phases is understandable because of the detailed and complex requirements for PPP preparation, and the difficulty in managing a long-term concession period. The project identification, procurement and implementation phases also attracted significant amount of research on distinct topics. By contrast, very little literature has been identified on the transfer phase possibly because limited number of projects have reached this phase. Quite a few papers referred to indivisible topics given that they cannot be classified into any single phase appropriately, which may show that system thinking is critical for PPP development.

On the basis of the life cycle taxonomy, extensive literature analysis and a series of future studies have been presented. Particularly, this study suggested that the transfer phase, which is the end of a PPP contract life cycle as well as the start point of post-transfer operation, required more comprehensive studies as problematic transfer process has been observed while little has been known about this phase. Other future studies, such as risk allocation on the identification phase, optimization of mathematical models on the preparation phase, concessionaire selection on the procurement phase, risk management on the implementation phase, as well as the application introduction on the indivisible topics etc., have also been recommended. The study built the connection between important project problems and PPP phases, from which PPP practitioners may be benefited as they can know better about what problems need to be particularly considered in certain phase. Researchers may be inspired by the research outcomes to nourish the existing body of PPP knowledge by focusing on phases that have been underrated previously.

In this research, aside from the seven selected journals, some other PPP-related journals and papers may be excluded on the list. However, the analysis showed that the 282 papers can cover the whole concession life cycle and reflect the recent research status effectively. Yet, this study merely provided an overview of research throughout the PPP life cycle; particular phase can be studied more in-depth in the future. Moreover, although the classification of papers was based on well-designed procedures that aim to improve objectivity, the authors admit the possibility of some subjectivity. Thus, comparative research using bibliographic analysis software could be carried out to confirm the result of this paper. Additionally, apart from the phases restricted by PPP contract, the post-transfer phase is also an area for further exploration.

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## Figure Captions

**Fig. 1.** Investment and number of PPP infrastructure projects during 1990-2014 (Data from World Bank 2016)

**Fig. 2.** Phases of PIPLC (Adapted from EIB 2012; MOF 2014)

**Fig. 3.** Complete distribution of existing research and future studies

**Fig. 4.** Annual number of papers for each phase (category)

**Table 1.** Number of Papers in Selected Journals from 1996 to 2016

Journal Title	Number of Papers
Journal of Construction Engineering and Management	78
International Journal of Project Management	67
Construction Management and Economics	52
Journal of Management in Engineering	41

Journal of Infrastructure Systems	21
Engineering Construction and Architectural Management	18
Proceedings of Institution of Civil Engineers: Civil Engineering	5
Total	282

**Table 2.** Top five of the most-mentioned countries/jurisdictions in research on application introduction

Countries/Jurisdictions	Mentioned times
China	12
United Kingdom	5
Australia	4
Hong Kong	4
United States	3