Conceptual Framework for the Performance Measurement of Public-Private Partnerships

Junxiao Liu[1]; Peter E. D. Love[2]; Peter R. Davis[3]; Jim Smith[4]; and Michael Regan[5]

Abstract: Public-private partnerships (PPPs) have been used widely to deliver economic and social infrastructure projects. There has been widespread debate about the factors that contribute to their success and failure. Critical to their successful implementation is effective performance measurement of the projects. With this in mind, a comprehensive review of the normative literature in association with PPPs (e.g., critical success factors, roles of public sector, concessionaire selection, risk management, cost and time issues, and finance) is undertaken and a conceptual framework for dynamic life-cycle is proposed. The paper provides both public sector and private entities with an insight into effective and efficient performance measurement within the context of PPP infrastructure projects. **DOI: 10.1061/(ASCE)IS.1943-555X.0000210.** *© 2014 American Society of Civil Engineers.*

Author keywords: Performance measurement; Public-private partnerships; Infrastructure projects.

Introduction

Over the last 20 years, the delivery of infrastructure projects using public-private partnerships (PPPs) has enabled governments to better provide public services, such as health, education, water supply, transport, and electric power to communities (Pongsiri 2002). There have been many PPP successes and some failures reported in the normative literature (Hodge 2004; Regan et al. 2011a, b), though debate about their use has moved beyond ideological arguments about the advantages and disadvantages to focusing on how they can be structured to achieve public policy goals (Yong 2010). "To achieve the potential benefits that can be provided by PPPs they must be designed to deliver performance improvements within a framework that shares costs and risks between the public and private sectors" (Yong 2010).

The PPP markets of Australia and the United Kingdom, for example, are considered to be sophisticated and mature (Hodge 2004). Yet, despite their maturity with implementing PPPs, ineffective performance measurement has been identified as a factor that has contributed to the problems associated with the delivery of the Latrobe Regional Hospital and Deer Park Women's Prison in Victoria, Australia, and Ashfield Prison in the United Kingdom (VAGO 2002; House of Commons 2003; Roth 2004). According to Yuan et al. (2009), the absence of effective performance measurement in PPPs acts as a trigger for producing below optimum service quality of infrastructure. However, many PPP projects have not undergone a comprehensive form of ex post evaluation in terms of what has been delivered (Hodge 2005; Regan et al. 2011b), and limited research has been undertaken to discuss how to comprehensively measure PPP infrastructure project performance (Hodge and Greve 2007; Yuan et al. 2009). There is widespread consensus that performance measurement plays a decisive role in business success, particularly at the project level (Love and Holt 2000; Kagioglou et al. 2001; Bassioni et al. 2004; Qureshi et al. 2009). Moreover, monitoring and measuring performance are the core activities of contract and project management, which is an essential part of PPP policy in most countries, especially Australia and the United Kingdom (Chinyio and Gameson 2009; EIB 2012). Against this contextual backdrop, this paper provides a review of the literature on PPPs and construction project evaluations, and proposes a conceptual dynamic life-cycle performance measurement framework for PPP infrastructure projects.

Scope of PPP Research

Various definitions of PPP can be found in the normative literature. For example, the European Investment Bank (EIB 2004) suggests that PPPs are "the relationships formed between private sector and public bodies often with the aim of introducing private sector resources and/or expertise in order to provide and deliver public sector assets and services." The Public Private Infrastructure Advisory Facility (PPIAF) in Europe provides a definition in which a PPP "involves the private sector in aspects of the provision of infrastructure assets or of new or existing infrastructure services that have traditionally been provided by government." There is no universally accepted definition of a PPP and its meaning differs between countries. Essentially, governments embrace PPPs as they offer the following benefits (European Commission 2003):

- Accelerated infrastructure provision through allowing the public sector to translate capital expenditure into a flow of on-going service payments (income);

[1]Doctoral Scholar, School of Civil and Mechanical Engineering, Curtin Univ., Perth, WA 6845, Australia (corresponding author). E-mail: junxiao.liu@postgrad.curtin.edu.au

[2]John Curtin Distinguished Professor, School of Civil and Mechanical Engineering, Curtin Univ., Perth, WA 6845, Australia. E-mail: p.love@curtin.edu.au

[3]Professor, Faculty of Engineering and Built Environment, Univ. of Newcastle, Callaghan, NSW 2308, Australia. E-mail: peter.davis@newcastle.edu.au

[4]Professor, Institute of Sustainable Development and Architecture, Bond Univ., Gold Coast, QLD 4229, Australia. E-mail: jsmith@bond.edu.au

[5]Professor, Institute of Sustainable Development and Architecture, Bond Univ., Gold Coast, QLD 4229, Australia. E-mail: mregan@bond.edu.au

Note. This manuscript was submitted on June 1, 2013; approved on January 17, 2014; published online on March 11, 2014. Discussion period open until August 11, 2014; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Infrastructure Systems***, © ASCE, ISSN 1076-0342/04014023(15)/$25.00.

- Timely project implementation through the allocation of design and construction responsibility to private sector;
- Reduced whole life cost and motivated performance offered by the strong incentives of private sector to minimise costs and improve management over a project's life-cycle;
- Reduced government risk exposure by transferring such risks to private sector;
- Improved service quality and innovation through the use of private sector expertise and performance incentives; and
- Enhanced prudent management of public expenditure and reduced corruption by the increase in accountability and transparency.

The defining features of PPPs, against other forms of private participation in infrastructure, include risk transfer, long-term contract relationships and partnership agreements (Akintoye et al. 2003; Zhang 2004b). Kwak et al. (2009) state that "the complexity of contractual relationships between participants, and the long concession periods associated with PPPs, makes them distinct from a traditional infrastructure development routes." A review of the normative literature reveals that there are six core areas where research has been focused (Fig. 1):

1. Critical success factors (CSFs): CSFs are defined as "those few key areas of activity in which favourable results are absolutely necessary for a particular manager to reach his or her goals" (Rockart 1982). The identification of CSFs is considered to be the prerequisite in developing a PPP project protocol (Zhang 2005b). Hence, many studies have attempted to list the CSFs of PPP projects within the qualitative context (e.g., Tiong 1996; Qiao et al. 2001; Jefferies et al. 2002; Li et al. 2005a; Zhang 2005b; Jefferies 2006).
2. Roles and responsibilities of public sector: The public sector performs a pivotal role in facilitating PPP infrastructure projects (Tam and Leung 1997). A factor that has been identified as contributing to the failure of PPP projects is a lack of public sector support. A series of roles that the government can undertake to ensure the successful outcome of a PPP have been identified and include: (1) creating positive investment environment; (2) establishing sound regulatory framework and supportive authority; (3) selecting an appropriate concessionaire; and (4) constant involvement throughout a project's life-cycle (Kumaraswamy and Zhang 2001; Pongsiri 2002; Koch and Buser 2006; Abdel Aziz 2007).
3. Concessionaire selection: "A concessionaire is a consortium formed particularly for a PPP project" (Kwak et al. 2009). It is the principal participant mainly responsible for most of the stages of a PPP project. Zhang (2004a) suggests that the selection of a suitable concessionaire can significantly influence the success of a PPP project. A number of studies have been undertaken in an attempt to explain how to select the most suitable concessionaire for a PPP infrastructure project (e.g., Treasury Taskforce 1999; Ahadzi and Bowles 2001; Zhang and Kumaraswamy 2001; Zhang et al. 2002; Zhang 2004a, b, 2005a).

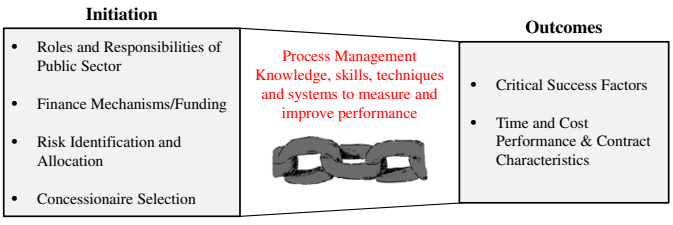

Fig. 1. Current scope of PPP: process management—the missing link

4. Risk management: Risk identification, analysis, and allocation are critical in PPP projects, where the liability of the private investor in design and construction is limited and the public sector primarily faces the financial and operational risks. A plethora of studies have examined PPP risks and have provided valuable insights into PPP risk identification and allocation (e.g., Charoenpornpattana and Minato 1999; Wang et al. 2000a, b; Grimsey and Lewis 2002; Thomas et al. 2003; Li et al. 2005b; Xenidis and Angelides 2005a, b; Nisar 2007; Sachs et al. 2007; Jin 2010, 2011; Xu et al. 2010; Chan et al. 2011). Fundamentally, risks in PPPs can be classified as the following: *market risks*, which arise due to uncertainties in the market demand for the infrastructure; *planning risks*, which arise from planning for private sector participation; *project risks*, which relate to uncertainties in construction, completion, operation and financing; *political risks*, which relate to wars, civil disturbances, and breach of contract; *regulatory risks*, which arise from a lack of suitably developed regulatory system; and *systemic risks*, which arise owing to fluctuations in exchange rates and changes in interest rates.
5. PPP cost, time and contract characteristics: It is common knowledge that cost and time savings center in any PPP infrastructure projects. In the literature, the *time* and *cost* performance of PPPs is implicitly linked to the project CSFs (NAO 2003; Raisbeck et al. 2010). Further, the characteristics of PPP contracts are significantly relevant to the cost and time of the projects. Considering this perspective, many researchers have explored PPP cost and time issues in association with the characteristics of specific contracting approaches (Herbsman and Glagola 1998; Zietlow 2005; Anastasopoulos et al. 2009, 2010b, c, 2013b).
6. PPP finance: The success of a PPP project depends largely on well-planned financing. However, financing a PPP project is characterized as a difficult and complex task. This is because of the sheer number of internal and external factors that must be considered when initiating a PPP financing plan. A number of studies have attempted to uncover the complexity of PPP finance in areas such as the financing strategy and financial engineering (Levy 1996; Merna and Dubey 1998; Ye and Tiong 2000; Schaufelberger and Wipadapisutand 2003; Zhang 2005c; Devapriya 2006).

While an array of studies have investigated the initiation and outcome of PPPs over the past two decades, there have been limited attempts to examine them from a process management perspective (see Fig. 1) (Yuan et al. 2009; Liu et al. 2013). Process management is important for business success, whether it is at the organizational or project levels (Kagioglou et al. 2001). Theoretically, process management is an application of knowledge, skills, techniques, and systems to measure and improve the process to satisfy customer requirements (Smith and Fingar 2003). Effective and competitive processes are critical success factors for PPP projects (Jefferies et al. 2002; Koppenjan 2005). Performance measurement forms the heart of process management (Lebas 1995; Bititchi et al. 1997), but has surprisingly received limited attention within the project life-cycle of PPPs (Robinson and Scott 2009; Yuan et al. 2009; Liu et al. 2013).

Performance Measurements in PPP Projects

Performance measurement is a process of quantifying and reporting the effectiveness and efficiency of the action performed towards influencing organizational objectives (Lebas 1995; Neely et al. 2005). Strategic objectives form the foundations of performance

measurement (Solomon and Young 2007). PPP infrastructure projects have a common strategic objective: the achievement of best value, which emphasises efficiency, value for money (V*f*M) and performance standards (Akintoye et al. 2003; Zhang 2006b). This strategic objective covers the issues in relation to the "public client's overall strategic plan and mission objectives, private sector's long-term development and payoff strategy, the general public's requirements of quality public facilities and services" (Yuan et al. 2009). V*f*M is a key component of best value. It has been viewed as the principal benchmark of the strategic objective of PPPs in the majority of the countries across the world (Akintoye et al. 2003; Grimsey and Lewis 2005; Henjewele et al. 2011). The Treasury Taskforce (1998) of the United Kingdom states that PPPs should be used only if they provide better V*f*M than traditional procurement. The Office of Government Commerce in the United Kingdom (2002) defines V*f*M as "the optimum combination of whole life cost and quality to meet the user's requirement." V*f*M focuses on overall outcomes achieved, covering a wide range of issues within qualitative and quantitative contexts such as whole life cost, service quality, maintainability, social benefits, and sustainability (Partnerships Victoria 2001; Department of Treasury and Finance 2007).

The V*f*M of PPP projects in Australia and the United Kingdom is typically determined and revealed by the *public sector comparator* (PSC) (Treasury Taskforce 1999). The PSC is a comparison between the cost of proposed PPP projects and the benchmark cost, which is a cost estimation of the specific service using traditional procurement (Grimsey and Lewis 2005). Due to the PSC's focus on cost, the evaluations of PPP projects in Australia and the United Kingdom have been oversimplified (NAO 2000; Department of Transport 2002; Fitzgerald 2004; Allen Consulting Group 2007). In the rest of the world (e.g., EU countries other than the United Kingdom, the United States, South America, Africa, New Zealand, and Asia), cost performance also plays a dominant role in PPP project evaluations (Haskins et al. 2002; Sachs et al. 2005; Blanc-Brude et al. 2006; Anastasopoulos et al. 2011). Some values of PPPs in infrastructure development may not be entirely reflected by cost, but expanded by other issues such as project completion time and project quality (Yong 2010). Public sector projects regularly experience cost and schedule growth, particularly those that have been procured using traditional procurement (Grimsey and Lewis 2004; Kwak et al. 2009). Thus, several studies attempted to incorporate *time* into the evaluations of PPPs (NAO 2003; Zietlow 2004; Raisbeck et al. 2010). Table 1 provides a summary of the key studies that are concerned with the evaluations of PPPs with the comparison of traditional lump-sum projects. It can be seen that PPPs have generally performed better than traditional projects (i.e., in-house), especially in cost savings, where 4.5–50% costs can be saved in various types of PPPs. While Raisbeck et al.'s (2010) research is akin to previous studies they reveal that PPPs generate slightly more (but almost negligible) project delays than traditional procurement (2.5% versus 2.3%).

The evaluation integrated with V*f*M in a PPP project is a complicated process, and the uses of absolute time and cost measurements do not reflect the complexity associated with PPP delivery (Office of Government Commerce 2002; European Commission 2003). Amos (2004) suggests that the evaluations of PPPs should involve the performance indicators of technical efficiency, allocative efficiency and financial performance. However, technical, allocative and financial measures are still insufficient to fully capture V*f*M, because such critical issues as key stakeholders' satisfactions (i.e., public client) cannot be addressed properly in these measurements (Henjewele et al. 2011).

Given the potential problems of evaluating PPPs, a comprehensive and strong evaluation is required for PPP projects (Hodge and Greve 2007). Yuan et al. (2009) propose an innovative performance measurement framework, namely *key performance indicators system* (KPIS), to comprehensively evaluate PPPs. The KPIS consists of five measurement aspects: (1) project's physical characteristics; (2) financial and marketing indicators; (3) innovation and learning indicators; (4) stakeholders' indicators; and (5) process indicators.

Despite the comprehensiveness of Yuan et al.'s (2009) proposed framework, issues associated with performance measurement have been largely ignored. In the case of stakeholder and process indicators, Neely et al. (2001) suggest that the relationship between organization and stakeholders is reciprocal in nature, and performance measurement should highlight not only stakeholder satisfaction, but also their contribution to the organizations. A development process of a PPP is more complex than that of traditional lump sum projects and it is divided into a series of phases (EIB 2012). Failing to assess the performance of each phase in PPPs may lead to that

Table 1. Key Findings of Studies of PPP Evaluations

Authors	PPP projects	Traditional lump sum projects
Arthur Anderson Enterprise LSE (2000)	Cost: 17% savings	N/A
NAO (2000)	Cost: 10–20% savings	N/A
Department of Transport (2002)	Cost: 20% overruns	N/A
Haskins et al. (2002)	Cost: 30–40% savings	N/A
Mott MacDonald (2002)	Cost: 50% savings	Time: 4–39% overruns Cost: 24–66% overruns
Pakkala (2002)	Cost: 14–20% savings	N/A
NAO (2003)	Time: 76% on time Cost: 78% on budget	Time: 30% on time Cost: 27% on budget
Fitzgerald (2004)	Cost: 91% on budget	N/A
Liautaud (2004)	Cost: nearly 30% savings	N/A
Zietlow (2004)	Cost: 10–20% savings	N/A
Sachs et al. (2005)	Cost: 1–25% savings	N/A
Blanc-Brude et al. (2006)	Cost: 24% extra cost (ex ante evaluation)	N/A
NSW Auditor-General (2006)	Cost: 7–23% savings	N/A
Allen Consulting Group (2007)	Cost: 11% savings	N/A
Anastasopoulos et al. (2010a)	Cost: 4.53% savings	N/A
Raisbeck et al. (2010)	Time: 2.5% overruns Cost: 1.2–11.6% overruns	Time: 2.3% overruns Cost: 13.8–91.5% overruns
Anastasopoulos et al. (2011)	Significant cost savings	N/A

the evaluation for the underlying projects cannot comprehensively measure the project performance on the basis of V*f*M (Henjewele et al. 2011; Liu et al. 2013).

Performance Measurement in Construction

Designing a performance measurement framework to measure business and project related processes is a complex and challenging task. The concept of performance measurement has received a considerable amount attention as it is a critical activity that organizations must perform in order to achieve their strategic goals (Neely et al. 2005), especially for those operating in the construction industry where both organizational and project goals need to be met (Love and Holt 2000; Bassioni et al. 2004). Performance measurement in construction has been focused on three levels: (1) industry; (2) corporate; and (3) project (Elyamany et al. 2007), with emphasis being placed on key performance indicators (KPIs) and performance measurement systems (Bassioni et al. 2004; Haponava and Al-Jibouri 2012).

"KPIs are measures that are indicative of performance of associated process" (Beatham et al. 2004). Establishing KPIs have become the most popular performance measurement metric in the construction sector (Bassioni et al. 2004; Beatham et al. 2004; Chan and Chan 2004; Haponava and Al-Jibouri 2010; Lai and Lam 2010). Table 2 identifies the KPIs that have been developed in relation to the performance measurement of construction projects. Most construction organizations measure performance on the basis of traditional quantitative methods, such as financial reports and at the project level using time, cost, quality, and safety. Although KPIs have been widely applied in performance measurement in construction, their use has received a great deal of criticism. For instance, Bassioni et al. (2004) contend that the use of KPIs for internal decision-making processes is limited as they provide no insight into performance improvement. Moreover, KPIs are lagging indicators and thus cannot be used in monitoring and improving the work when the project is under construction (Kagioglou et al. 2001; Haponava and Al-Jibouri 2012).

Apart from KPIs, performance management systems (PMSs) have also been considered in construction (Alarcon and Ashley 1996; Kagioglou et al. 2001; Bassioni et al. 2005; Luu et al. 2008a; Chan 2009). A PMS "is a structure in which strategic, tactical and operational actions are linked to process to provide the information required to improve the program or service on a systematic basis" (del-Rey-Chamorro et al. 2003, p.47). Despite their widespread application in construction, PMSs have normally been used at the industry and company levels with only limited number of studies examining the project level (Bassioni et al. 2005; Luu et al. 2008; Chan 2009). For example, Alarcon and Ashley (1996) developed a general performance model (GPM) and Kagioglou et al. (2001) proposed a balanced scorecard (BSC) that encompasses the *project perspective* for the purpose of systematically measuring construction project performance.

The review above suggests that performance measurement in construction has solely focused on product-oriented measures. This means that the existing KPIs and PMSs designed for construction project evaluations are established after project completion. For example, the KPIS proposed by Yuan et al. (2009) for the life-cycle of a PPP is product-orientated in nature. The product-based project evaluation cannot provide an insight into the performance of a process (Haponava and Al-Jibouri 2012). It has been acknowledged that the endogenous and exogenous factors that can substantially affect the project success change dynamically over the project's life-cycle (Sidwell 1990). According to Haponava and Al-Jibouri (2012), the lack of a life-cycle perspective to performance measurement juxtaposed with dynamic measures can contribute to inefficient and ineffective decision making. Yet, despite the importance of dynamic life-cycle performance measurement, it remains an area that has received limited attention at the project decision-making level in construction.

Table 2. KPIs at the Construction Project Level

Authors	Aspects for measurement	Measurement levels
Kumaraswamy and Thorpe (1996)	Cost/financial, project duration, quality, health and safety, quality of workmanship, functionality/utility	Project
Songer and Molenaar (1997)	Cost/financial, project duration, quality, client and project manager satisfaction, user expectation and satisfaction, quality of workmanship, meeting specification, dispute minimization	Project
Lim and Mohamed (1999)	Cost/financial, project duration, quality, client and project manager satisfaction, user expectation and satisfaction, quality of workmanship, health and safety, functionality/utility	Project
Love and Holt (2000)	Product, service performance, corporate ability, individual ability, productivity, quality, environment, and financial aspects	Company
Cox et al. (2003)	Time, cost, quality, safety, and productivity	Company and project
Chan and Chan (2004)	Cost/financial, project duration, quality, speed of construction, transfer of technology, quality of workmanship, health and safety	Project
Sohail and Baldwin (2004)	Time, cost, quality, stakeholders' roles and responsibilities, partnership, and social-economic factors	Project
Luu et al. (2008b)	Time, cost/financial, quality, safety, customer satisfaction, project team performance, change and material management	Project
Haponava and Al-Jibouri (2010)	Time, cost/financial, quality, safety, value and objective, stakeholders' requirements, and communication	Project
Hwang et al. (2010)	Schedule (time), cost/financial, and dimension (space)	Project
Lai and Lam (2010)	Time, profit, environment, quality, safety, effectiveness of process, level of dispute, staff satisfaction, and innovation	Project
Idrus et al. (2011)	Quality of finished project, construction cost, construction time, occupational health and safety, labour dependency, contractor's project management, quality of coordination by the construction team, contractor's manpower capacity, construction flexibility, environment friendliness, level of technology	Project

Propagation of a PPP Dynamic Life-Cycle Performance Measurement Framework

Evaluating PPP projects is more difficult than that of traditional projects as there are many components (e.g., documentation, financing, taxation, technical details, and subagreements) and risks (e.g., market risks and project risks) arising from the complexity of the long-term contractual arrangement and they can change dynamically and substantially over the projects' life-cycles (Grimsey and Lewis 2002; Robinson and Scott 2009; Raisbeck et al. 2010). The traditional development process of a PPP infrastructure project contains eight stages (e.g., project selection and definition, PPP option assessment, getting organised, pretendering work, bidding process, contract and financial close, contract management, and ex post evaluation) with the project being subjected to evaluation in the final phase (EIB 2012). This kind of evaluation, as noted above, is a product-oriented measurement where the measure for project performance is simply a review (Haponava and Al-Jibouri 2012).

The aforementioned eight stages of the development process of a PPP can be summarized into three major interrelated phases: (1) *Initiation and Planning*; (2) *Procurement*; and (3) *Partnership* (e.g., construction, operation, and maintenance) (EIB 2012). These phases are referred to as the PPP project life-cycle. A PPP project has a dynamic and constantly evolving process (Chinyio and Gameson 2009); therefore, the product-oriented evaluation cannot effectively assist project managers to control and improve the processes associated with the delivery of an asset. Haponava and Al-Jibouri (2012) proffer that the PMSs designed for construction projects should concentrate on the process-based evaluation where evaluation for each project phase is a focus, rather than the *static* product-based measure. Bearing this perspective in mind, it suggests that a dynamic life-cycle perspective needs to be used to measure the performance of PPPs and a phase-based evaluation is required to replace the traditional product-oriented approach.

Understanding the underlying needs and requirements of stakeholders involved with the delivery of a PPP is an essential part of a performance evaluation model. At the project level, "stakeholders are individuals or organizations that are affected by or affect the development of the project" (El-Gohary et al. 2006). PPP stakeholders include government, consumers, investors, and even employees (e.g., public client, concession contractors, financiers, consultants, and end-users) (ADB 2008). An effective integration of a set of stakeholders is imperative for delivering successful PPPs (Yong 2010).

PPP projects are normally undertaken by a *special purpose vehicle* (SPV), which is a consortium responsible for developing, building, operating, and maintaining an asset that is procured over the concession period (Zheng et al. 2008; Yong 2010). SPVs exhibit a dual character, implying that they are operating in the context where goals at company and project levels must be met. Hence, the evaluation related to SPVs should focus on the outputs at both company and project levels. Accordingly, the PMSs integrated with the project-related issue is deemed to be more suitable for PPP evaluation than the use of sole KPIs as KPIs focus on project rather than company performance (Kagioglou et al. 2001). Corporate-related issues (i.e., strategies) cannot be addressed properly in the KPI framework. Several PMSs have been adapted to measure project performance in construction (e.g., Alarcon and Ashley 1996; Kagioglou et al. 2001; Yuan et al. 2009); however, most of the developed systems originate from the BSC (e.g., Kagioglou et al. 2001; Yuan et al. 2009).

Over the last two decades, the BSC has been the most reputable PMS applied widely across industries (Kennerley and Neely 2003). Despite its widespread application, the BSC has been the subject of extensive criticism. Neely et al. (2001) criticized some measures of the BSC as too narrow to capture the factors essential to business success. For example, the view of stakeholders in the BSC encompasses only customers and shareholders, and neglects suppliers, alliance partners, employees, regulators, and local community or pressure groups, all of which are critical to the performance and success of an organization/project. Moreover, the BSC fails to highlight "the relationship between the measures proposed for certain goals" (Kagioglou et al. 2001), and no mention is made to the contribution of stakeholders to organization (Mooraj et al. 1999). In summary, the components of the BSC cannot keep pace with the increasingly changing nature of today's business, especially under the conditions of multiple stakeholder integration (Neely et al. 2001).

One important principle in performance measurement is that the developed measures must reflect the context to which they are applied (Neely 1999). As mentioned above, effective involvement of multiple stakeholders is crucial to PPP project success. Nevertheless, the BSC has deficiencies in measuring organizational performance against a multiple-stakeholder environment. For that matter, it cannot comprehensively capture the nature and context in which PPPs operate, and thus the BSC is an inappropriate choice for PPP evaluation. On the basis of the characteristics of PPPs, a performance measurement framework that deals with the complexity triggered by multiple stakeholders is an ideal tool to underpin the performance measurement of PPP projects (Liu et al. 2013). Thereby, the *performance prism* is deemed to be more suitable as it is a more holistic framework structured to shed light on the complexity derived from multiple stakeholders and assist with directing and guiding performance measurement design for long-term success in a particular business environment (Neely et al. 2001). In addition, the performance prism addresses the reciprocal relationship between the organization and stakeholders, which is capable to indicate not only how key stakeholders contribute to business success, but also what such contributions must be strengthened to improve the performance of an organization (Neely et al. 2002).

The performance prism consists of five interrelated facets designed for measurement (Fig. 2) (Neely et al. 2001).

1. Stakeholder satisfaction: who are our stakeholders and what do they want and need?
2. Strategies: what strategies do we need to satisfy these sets of wants and needs?
3. Processes: what processes do we need to allow our strategies to be delivered?
4. Capabilities: what capabilities (people, practice, technology and infrastructure) do we need to put in place to allow us to operate our processes?
5. Stakeholder contribution: what do we want and need from our stakeholders?

According to Neely et al. (2001), the "Performance prism is a framework—a tool—which can be used by management teams to influence their thinking about what the key questions are that they want to address when seeking to manage their business." Considering this perspective, as well as the five measurement facets, a set of core indicators (CIs) can be derived from the normative literature within the context of PPP performance measurement (Fig. 2 and Appendix).

The life-cycle perspective, as discussed above, needs to be applied in PPP evaluations. It is noted that a life-cycle of a PPP project is comprised of three main phases (EIB 2012). So, the life-cycle

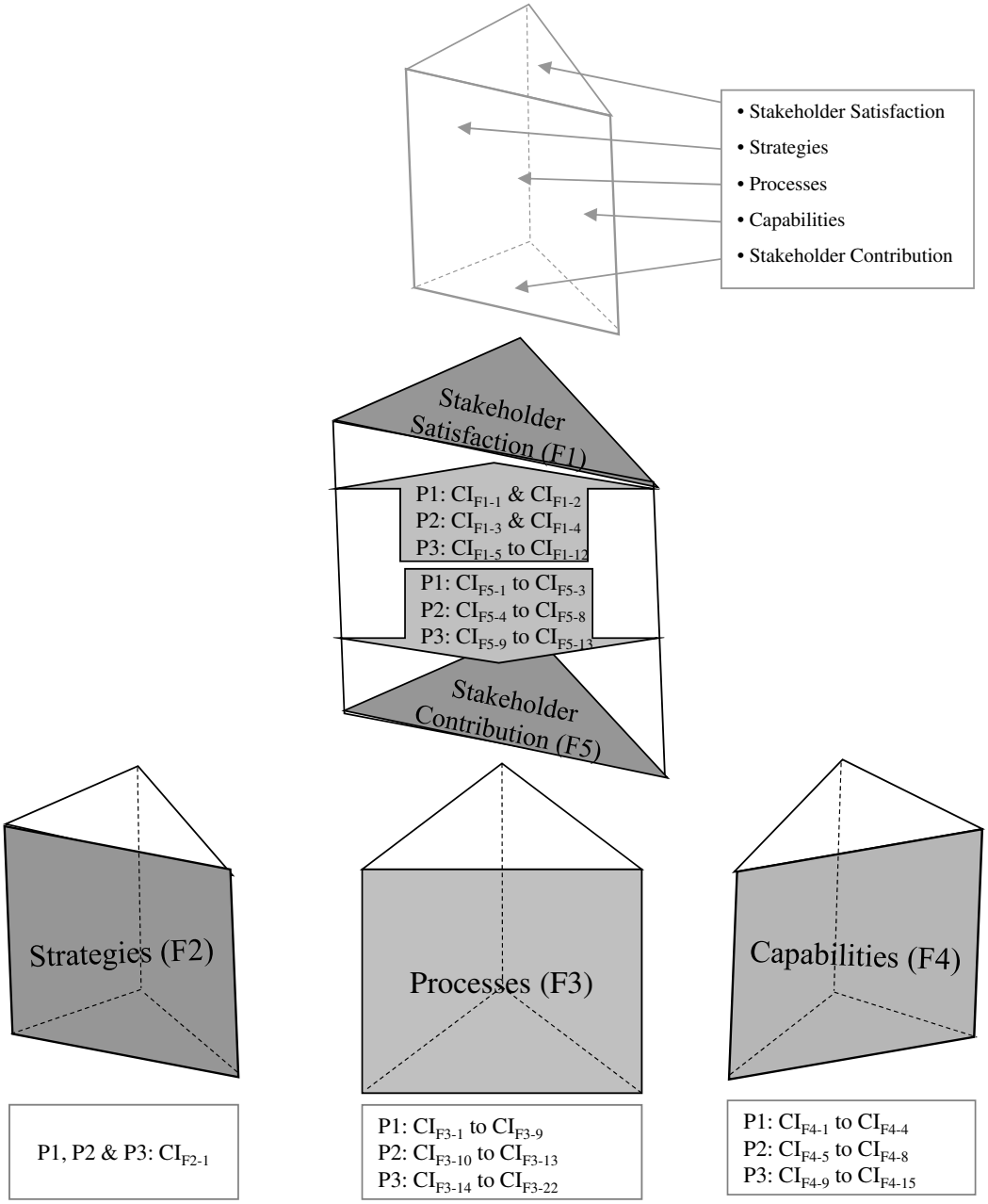

Fig. 2. Performance prism within the context of PPPs (adapted from Neely et al. 2001, with permission from Emerald Group Publishing Limited)

PMS to be developed is a phase-based evaluation framework. Generally, there are two kinds of evaluation at the project level in construction: (1) ex ante evaluation and (2) ex post evaluation. Ex ante evaluation is a preproject study that is applied to offer assistance in investment decision making on the basis of the calculations of feasibility and cost, while ex post evaluation is a comparison between expected outcomes and actual achievements and it provides insight into the management of future work (Farbey et al. 1992; Irani et al. 2001, 2005). In short, normally, two *evaluation nodes* can be seen in the evaluation systems of PPP projects, either at the initiation stage or at the end of the project. However, these kinds of evaluation fail to effectively and efficiently control the whole development process of a project (Haponava and Al-Jibouri 2012). To shift the evaluations of PPPs from ex ante and ex post evaluations to a comprehensive life-cycle performance evaluation, two additional evaluation nodes are placed at the interfaces between pretendering and bidding and contract and financial close and contract management (see Fig. 3). These four evaluation nodes are designed for project managers to measure project performance in each life-cycle phase under the CIs identified in the Appendix and Fig. 2.

The life-cycle evaluation is specifically dependent upon the implementation of business process management, where continuous improvement over the project life-cycle forms an integral part of its delivery strategy (Pedler et al. 1991). *Organizational learning* has been identified as a vehicle for delivering continuous improvement and incremental innovation in business processes (Buckler 1996; Scarbrough et al. 1998). To facilitate a learning organization, particularly for construction firms, the mechanisms that stimulate a learning and innovation culture must be embraced (Kululanga et al. 2001). However, few construction organizations have systems or mechanisms to capture and absorb their lessons learned or express their interest in doing so (Love et al. 2003). To shed light on this field, *learning mechanisms* have been embedded into the developed

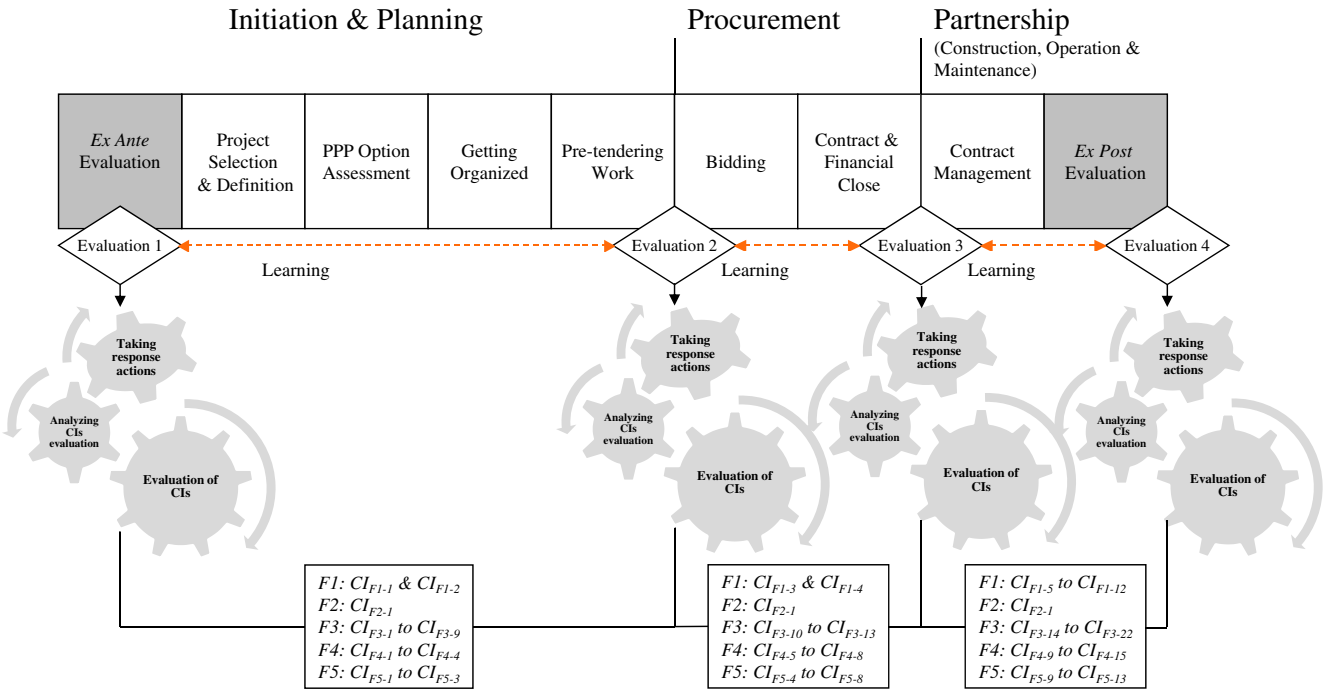

Fig. 3. Dynamic life-cycle performance measurement framework of PPP projects

performance measurement framework (Fig. 3). These mechanisms act as stimulators that can assist organizations to systematically acquire their lessons learned (Love et al. 2004). Such lessons may contribute to developing an organization's *learning capability*, which is a key enabler for business growth and success (Buckler 1996; Wang and Ahmed 2003).

Based on these issues, PPP project managers can use the proposed life-cycle PMS (Figs. 2 and 3) to grasp the performance information with regard to the project through conducting a series of evaluations by analyzing the developed CIs at each evaluation node, and then identify areas for future improvements and changes on the basis of the lessons learned by the learning mechanisms and take response actions to maintain satisfactory project performance and finally achieve project success (see Fig. 3). In other words, such CIs under the developed life-cycle PMS possess the nature of lead indicators, as they are supported by learning processes and thus are capable to benefit the key stakeholders of PPPs by providing assistance in investment decision making as well as real-time performance review, which aims to identify how well resources have been utilized in previous phase, what actions must be taken immediately for improvement, and what aspects should be controlled and focused in next phase.

Stakeholder Satisfaction (F1)

Stakeholder satisfaction is highly important for performance measurement, especially within the context of multiple stakeholders. The performance prism commences with the facet of stakeholder satisfaction as satisfying stakeholders' wants and needs is the baseline for the existence of organization (Neely et al. 2001, 2002).

Throughout a PPP's life-cycle, the SPV exists to satisfy a public client's requirements, which focus on providing a service to the public using private-sector investment (Pongsiri 2002; ADB 2008; Zheng et al. 2008; Chinyio and Gameson 2009). The public sector client is actively involved in each of the project's life-cycle phases (Kwak et al. 2009). Hence, the satisfaction of public client (CI_{F1-1}, CI_{F1-3}, and CI_{F1-5}) must be addressed over a PPP project's life, and the user satisfaction (CI_{F1-12}) needs to be raised when conducting the performance measurement after the infrastructure is operational. Furthermore, the general concessionaire is involved with PPP projects from the procurement phase, during which the finance structuring of PPPs is completed. A number of financial mechanisms can be used to fund PPP projects, such as equity and bank debts, loans and bonds (Chinyio and Gameson 2009; Yong 2010; Regan et al. 2011a). Accordingly, general contractor, shareholders and creditors (e.g., banks, insurance/pension corporations, and multilateral agencies) can be deemed as the essential stakeholders of PPPs in the partnership phase. Thereby, it is rational to launch the CIs in relation to the satisfaction of general concession contractor, shareholders and creditors (CI_{F1-7}, CI_{F1-10} and CI_{F1-11}) in the partnership phase. Noteworthy, lenders bring discipline to a project by keeping pressure on the contractor to observe loan covenants. Banks are tougher taskmasters with PPPs than government agencies, and thus this role is worth highlighting when discussing stakeholders' satisfaction in PPP projects.

After the appointment of a general concession contractor, subcontractors and suppliers will be gradually engaged to participate in the construction of the asset. General contractors should maintain a good relationship with all stakeholders in order to ensure satisfactory progress throughout the project's life (NAO 2001). Kumaraswamy and Anvuur (2008) suggest that the relationship between general contractors and subcontractors as well as suppliers plays a more important role in the construction of PPPs than that of traditional lump sum projects. So, the contractor's ability to maintain relationships with subcontractors and suppliers to ensure their satisfaction (CI_{F1-8} and CI_{F1-9}) is a determinant of PPP performance (Davis and Love 2011).

Over the past decade, employees have been acknowledged by management researchers as the organization's key stakeholders (Bourne et al. 2003). In PPP projects, many employees, such as advisors and consultants, must be employed to deal with the problems associated with taxes, accounting, legal, and the environment (Yong 2010). Their satisfaction for many aspects, such as salary, workplace safety, and working environment, can significantly affect

the project performance. To address this prevailing issue, the CIs of the employee satisfaction construct ($CI_{F1\text{-}2}$, $CI_{F1\text{-}4}$, and $CI_{F1\text{-}6}$) are represented in all PPP phases, indicated in the Appendix.

Strategies (F2)

Strategy, in any organization, is not only the foundation of internal business processes, but also stakeholders' behavioral goal (Neely et al. 2001, 2002). Without an appropriate strategy, it is impossible for internal business processes to effectively deliver satisfactory services or products to customers, and employees will be confused about what matters and how they should behave to achieve success (Neely et al. 2002; Bourne et al. 2003). A common strategy of PPP infrastructure projects is the realization of V*f*M (Akintoye et al. 2003; Zhang 2006b; Yuan et al. 2009). V*f*M has been acknowledged as the fundamental management philosophy that penetrates through the whole life-cycle of PPPs (Treasury Taskforce 1998; Arthur Anderson Enterprise LSE 2000; Grimsey and Lewis 2005; Henjewele et al. 2011).

Broadly speaking, V*f*M is the optimum combination of life-cycle cost and quality (physical quality and service quality) under user requirements and a specified timeframe (Partnership Victoria 2001). According to this definition, the assessment used to examine V*f*M in PPP evaluations should be concerned with project life-cycle cost as well as quality within the framework of the user satisfaction and project schedule. In other words, the CI of V*f*M ($CI_{F2\text{-}1}$) ought to constitute project life-cycle cost, physical and service quality of the asset, project duration and end-user satisfaction. Noteworthy, V*f*M is a concept covering a variety of issues and the measurement facets of the performance prism are interconnected; therefore, there are overlaps between the measures identified from the performance prism for evaluating PPPs. Take project quality, duration, and end-user satisfaction, for example. They are also the core components of the *Stakeholder Satisfaction* facet and *Process* facet, respectively. As a result, life-cycle cost is the only issue discussed here, and the other three indicators are demonstrated in the *Stakeholder Satisfaction* and *Process* sections.

Life-cycle cost, normally, is the most important factor that must be considered in any PPP before the implementation of the project and it is complex. This complexity is derived from various factors. According to Sing et al. (2013), time, contract, price, human factors, and variations to scope are the determinants of the final costs of construction projects. In fact, a project's life-cycle is dynamic and can result in a substantial change in the predetermined cost of the project. However, in PPPs, the examination of the whole life cost is either an ex ante estimation or an ex post assessment, and there is no mechanism to control and improve the cost performance throughout the project's life. With this in mind, the measurement designed for project life-cycle cost performance in the developed PMS is a constant cost assessment that incorporates not only the pre-project estimation and postimplementation examination, but also a process-based monitoring (see Fig. 2). The major aim of doing so is to capture the dynamic nature of the project life-cycle and provide the key stakeholders with a dynamic insight into the life-cycle cost of the project so as to achieve significant cost savings.

Processes (F3)

To achieve V*f*M, it is necessary for both public sector and SPV to group appropriate internal business processes throughout the PPP project life. Within the framework of the Performance Prism, the measure of processes is used to identify what internal business processes should be improved to increase the effectiveness of the whole workflow (Neely et al. 2002).

Appendix identifies core process indicators for all phases of a PPP infrastructure project. In the PPP Initiation and Planning phase, a series of tasks are identified, including preproject environment analysis (political, economic, social, and legal), service need and desired output defining, risk management (identification, analysis, and allocation), and project structuring (financing, commercial, technical, and engineering) (Chinyio and Gameson 2009; EIB 2012). The performance quality of these aforementioned activities is a critical metric to evaluate the effectiveness and efficiency of the processes associated with PPP initiation and planning (Yuan et al. 2009; Yong 2010). Consequently, a set of CIs ($CI_{F3\text{-}1}$, $CI_{F3\text{-}2}$, $CI_{F3\text{-}3}$, $CI_{F3\text{-}5}$ and $CI_{F3\text{-}8}$) can be rationally derived. Noteworthy, the CI relating to the feasibility study ($CI_{F3\text{-}4}$) should not be neglected in project initiation and planning as it (e.g., affordability, bankability, constructability, and maintainability) has been identified as a critical success factor for PPPs (Zhang 2006a, b; EIB 2012). Additionally, it is essential to emphasize the CIs with regard to concession issues (e.g., selection criteria of concessionaire and concession period) ($CI_{F3\text{-}6}$ and $CI_{F3\text{-}7}$). There is a widespread consensus that an appropriate concession contractor and a reasonable concession period are critical to PPP project success. Zhang (2004a, b) and Salman et al. (2007) support this argument and identify the importance of appropriate concessionaire and concession period in the viability of PPP projects.

Bidding is an important function of the procurement of any PPP, in which activities such as prequalification, shortlisting, tender invitation, interaction with bidders, tender evaluation, and bidder selection must be conducted step by step (EIB 2012). Yuan et al. (2009) argue that a transparent and competitive bidding process is critical to the successful delivery of a PPP project and therefore the transparency and competitiveness of bidding procedure must be considered to be a process KPI of PPP projects. Based on this argument, it is reasonable to derive a CI of the transparency and competitiveness of bidding process ($CI_{F3\text{-}10}$) for the proposed life-cycle PMS.

After the completion of bidding, the PPP contract needs to be finalized under the final negotiation framework. This framework is vital and should typically include such issues as negotiation timetable and how to define and record the remaining problems and matters already agreed or settled (EIB 2012; Liu et al. 2013). Therefore, the core indicator of the comprehensiveness of final negotiation framework ($CI_{F3\text{-}11}$) is required. Additionally, the financial close of a PPP occurs in the procurement phase and it enables the funds (e.g., equity, loans, and debts) to start flowing to support the project implementation (Chinyio and Gameson 2009). SPV and public sector need to "carry out a considerable amount of detailed work to reach financial close" (EIB 2012). The work organized to reach financial close must be effective and efficient; otherwise, the progress of PPPs can be delayed (EIB 2012). For that matter, the CI regarding the effectiveness and efficiency of financial close ($CI_{F\text{-}12}$) is also worthy of being developed in PPP evaluation.

PPP projects enter the partnership phase (e.g., construction, operation, and maintenance) after the award of contract and financial close. The construction of the asset can last for several years, during which the indicators identified for traditionally procured projects can be used to evaluate the effectiveness of construction process, such as the TCQ (time, cost, and quality—physical and service quality) and material management ($CI_{F3\text{-}15}$) as well as health, safety and environmental impact ($CI_{F3\text{-}16}$) (Kagioglou et al. 2001; Partnership Victoria 2001; Zhang 2006a; Haponava and Al-Jibouri 2012).

An important activity in the partnership phase of a PPP project is contract management and it is critical to the success of the project. Several studies suggest that the effectiveness of contract management ($CI_{F3\text{-}17}$) must be considered in PPP evaluations (Zhang 2006a; Yuan et al. 2009). It is known that contract type plays an important role in PPP contract management. Hence, the evaluation for contract management in a PPP should encompass the characteristics of the contract, such as duration, service length/size, activities included, etc. In practice, there are typically six kinds of PPP contracts, including design-build (and its derivatives), warranty contracting, cost-plus-time (A+B Bidding) and incentives/disincentives, lane rental, and performance-based contracting (Anastasopoulos et al. 2013a). The characteristics of such contracts are relating to not only the project construction, operation and maintenance, but also to the project cost savings. Table 3 presents a brief pros and cons comparison of typical PPP contracts, by which project managers and evaluators in PPPs can understand what aspects they should be concerned when evaluating the project's contract management effectiveness.

The final phase of a PPP infrastructure project entails operating and maintaining the asset to deliver a required public service under a defined legal and contractual regulatory framework. Compliance of legal and regulatory framework ($CI_{F3\text{-}14}$), profit and profitability ($CI_{F3\text{-}19}$), and effectiveness of operations and facility management ($CI_{F3\text{-}20}$ and $CI_{F3\text{-}21}$) are attractive points in the process evaluation of PPPs (Yuan et al. 2009). Moreover, PPPs are being run within the context of multiple stakeholders, and thus the effectiveness of dispute resolution ($CI_{F3\text{-}18}$) and effectiveness of interface management ($CI_{F3\text{-}22}$) are of the important process indicators in relation to the Partnership phase (Yuan et al. 2009).

It can be noted from Appendix that the CIs of interface management (IM) ($CI_{F3\text{-}9}$, $CI_{F3\text{-}13}$ and $CI_{F3\text{-}22}$) penetrate the whole life-cycle of a PPP project. The IM can be defined as "the management of communication, coordination, and responsibility across a common boundary between two organizations, phases, or physical entities which are interdependent" (Chan et al. 2005). It is a set of managerial activities critical to PPPs, particularly those regarding the management and coordination between organizations, the phases of the project life-cycle, and physical entities (Chan et al. 2005). With this in mind, the identification of the CIs in regard to interface management over project's life is significant and necessary.

Capabilities (F4)

The operation of the business processes in organizations must be supported by certain skills, practical procedures, physical infrastructures and technologies, which are normally referred to as organizational capabilities (Neely et al. 2002). In the performance prism, the construct of capabilities is the least widely understood and it is established to measure whether the fundamental building blocks of organization's competitiveness are strong enough (Neely et al. 2001). The capabilities required to complete PPPs vary during the phases of the project's life-cycle. This is because of the project complexity of PPPs and the phase-based nature of the necessary detailed work designed to ensure the completion of the PPP development.

It has been acknowledged that employees are one of the most important components in any organization. So, skilled employees (e.g., advisors, consultants, and PPP experts) ($CI_{F4\text{-}1}$, $CI_{F4\text{-}5}$, and $CI_{F4\text{-}9}$) are a basic capability in SPV over the project's life-cycle. In addition, today's business environment changes dramatically. To maintain competitiveness, "how to enhance organization's learning ability" has been an attractive topic in management research (Denton 1998). For a PPP infrastructure project, the operating environment is more complicated than that of a traditional lump sum projects; thus, an effective and efficient training and learning system (responsible to develop the appropriate training programmes) on the basis of different phases of PPPs is undoubtedly required during the whole project. The training and learning system is considered to be a necessary supporting infrastructure in PPPs (Yuan et al. 2009). This is the reason why the CIs of training and learning system ($CI_{F4\text{-}2}$, $CI_{F4\text{-}6}$, and $CI_{F4\text{-}10}$) have been built up from the initiation and planning phase to partnership phase.

Developing the CIs of innovation ($CI_{F4\text{-}3}$, $CI_{F4\text{-}4}$, $CI_{F4\text{-}7}$, and $CI_{F4\text{-}14}$) is imperative in all project phases of a PPP. This is because organization's capability in innovation relates to project's performance in strategic planning, design, financing, procurement and construction (Shen et al. 2004). In short, innovation plays a vital role over the project life-cycle. In PPPs, financing is completed in the procurement phase and then construction commences. Accordingly, the measure for the capabilities of SPV in the post-transaction (construction, operation, and maintenance) should cover finance infrastructure ($CI_{F4\text{-}11}$), advanced technologies and equipment ($CI_{F4\text{-}13}$), and technology transfer ability ($CI_{F4\text{-}15}$). The research undertaken by Carrillo et al. (2006) explains that in PPP projects, technology transfer has a substantial impact on the performance of SPV in construction. Moreover, the CIs relevant to governance ($CI_{F4\text{-}8}$ and $CI_{F4\text{-}12}$) need to be placed in both the procurement and partnership phases. The contract of a PPP project includes a range of governance arrangements, such as the practices for monitoring and procedures for decision-making and problem solutions (NAO 2001). As a result, governance is significant for PPPs and it can substantially influence the performance of PPP construction, operation, and maintenance (Badshah 1998).

Stakeholder Contribution (F5)

The stakeholder contribution, as opposed to stakeholder satisfaction, is a measure for managing the dynamic tension between stakeholders and the organization (Neely et al. 2001). Specifically, the *Stakeholder Satisfaction* is applied to understand what stakeholders want and need from the organization, while the *Stakeholder Contribution* is designed to examine what the organization wants and needs from its key stakeholders. Take employees, for example, they want from their organizations a satisfactory salary, job security, safe work environment, and recognition. In return, the organizations want their employees to provide positive and valuable suggestions, work efficiently, and maintain loyalty (Neely et al. 2001). According to this point of view, the CIs, namely employees' performance ($CI_{F5\text{-}3}$, $CI_{F5\text{-}5}$, and $CI_{F5\text{-}10}$), must be addressed in all project phases of a PPP. These indicators assist to evaluate employees' creativity, productivity, and loyalty over a project's life.

In addition to employee contribution, PPP infrastructure projects should incorporate the support from the public client, general contractor, subcontractors, suppliers, shareholders and creditors (Chinyio and Gameson 2009). Kwak et al. (2009) summarize that public client's contributions in PPPs encompass the establishment of a favourable investment environment and legal framework in the project planning and design, selection of suitable concessionaire in the procurement, and active involvement of contract management after the project transaction. Therefore, it is appropriate to group the core indicators in association with the establishment of investment environment and legal framework ($CI_{F5\text{-}1}$ and $CI_{F5\text{-}2}$), concessionaire selection ($CI_{F5\text{-}4}$), and willingness to be actively involved ($CI_{F5\text{-}9}$). After PPPs move into the partnership phase, the performance of subcontractors and suppliers emerge to be a critical determinant of the project success (Chinyio and Gameson 2009).

Table 3. Comparison of Typical PPP Contracts

Types of PPPs	Descriptions	Benefits	Disadvantages	Suitability
Design-build (DB)/ Design-bid-build (DBB)/ Design-build-operate (DBO)	The private sector is responsible for the project's design, build, and finance as well as operations in some cases	• Easy administration; • Transparent and objective selection process (Pakkala 2002)	• Lack of innovation and life-cycle cost control; • Tendency for ordinary project quality; and • Possibility of order changes and cost overruns (Anastasopoulos et al. 2011)	These contracting approaches have been widely applied across the world and are suitable for social and economic infrastructure projects (Pakkala 2002)
Design-build-operate-maintain (DBOM)/ Design-build-finance-operate (DBFO)/ Design-build-finance-operate-maintain (DBFOM)	The private sector is responsible for the design, construction, operation, and maintenance or finance of a project	• High quality; • Favourable for innovation; and • Low risk in project failure (Pakkala 2002)	• More resources and skilled workers required (Pakkala 2002)	DBOM, DBFO and DBFOM are widely used in Australia, the UK and US. They suitable for social and economic infrastructure projects (Kwak et al. 2009)
Warranty contracting	In the warranty contracting, contractors must comply with a contract that is under an assurance that no undue defect and failure exist in the asset over its useful life. Otherwise, contractor is responsible for product repair and replacement (Anastasopoulos et al. 2011)	• Higher quality; • Higher longevity; • Cost effectiveness; and • Long-term cost savings (Singh et al. 2007)	• Higher initial construction costs (Singh et al. 2007)	This kind of contract is suitable for roadway preservation and rehabilitation, and it is commonly used in the US (Singh et al. 2007)
Cost-plus-time (A+B bidding) and incentives/disincentives (I/D)	Cost-plus-time and I/D consider not only the initial costs (e.g., construction, maintenance, and rehabilitation), but also the duration of the project in bidding	• Time savings; • Cost savings; and • Less road user impacts (Arditi and Yasamis 1998)	• Possibility of order changes; • Possibility of cost overruns; and • Possibility of schedule overruns (Pakkala 2002)	These kinds of contracting are widely applied in the US and it is suitable for roadway preservation projects (Anastasopoulos et al. 2013a)
Lane rental	Lane rental is a contracting approach that allows contractors to rent a lane for work during rush hour (Herbsman and Glagola 1998)	• Time savings; and • Cost savings	• High pressure on the resources of all parties involved; and • Risk in production and on-site safety	Lane rental is widely in the UK and US, and it is suitable for rehabilitation and reconstruction projects (Herbsman and Glagola 1998)
Performance-based contracting	The performance-based contracting is an approach under the contract that specifies the minimum physical performance of a road asset required to be procured within a predetermined timeframe (Zietlow 2004)	• Cost savings; • Less uncertainty of expenditure for public agencies; • Fewer agency staff required; • Higher customer satisfaction; and • Stable financing (Stankevich et al. 2005)	• Difficulty in the design of appropriate performance standards; and • Difficulty in determining the obligation of public agency (Stankevich et al. 2005)	The performance-based contracting is suitable for roadway maintenance. It has been widely used in Australia, Canada, UK, Finland, New Zealand, Sweden, the US, and Latin America (Pakkala 2002; Zietlow 2005)
Hybrid contracting	Hybrid contracting is the "contract agreement that incorporates different characteristics of a range of contract type" (ADB 2008, p.43)	• Significant cost savings; and • High sustainability (Anastasopoulos et al. 2013a)	• Difficult to be administrated due to contract complexity (ADB 2008)	The kind of contracting is suitable for not only road preservation projects, but also PPP mega projects (WSDOT 2013)

The lack of the CIs associated with subcontractors' and suppliers' contributions in the partnership phase can lead to the ineffectiveness of the project evaluation. For that matter, $CI_{F5\text{-}11}$ and $CI_{F5\text{-}12}$, namely subcontractors' performance and suppliers' performance, ought to be developed.

In the Appendix, under the *Stakeholder Contribution*, the CIs in relation to the willingness of private contractors, shareholders, creditors, and users to PPP participation ($CI_{F5\text{-}6}$, $CI_{F5\text{-}7}$, $CI_{F5\text{-}8}$, and $CI_{F5\text{-}13}$) have been constructed in the procurement and partnership phases. One of the case studies presented by Neely et al. (2001) shows that the measurement for stakeholder contribution should involve stakeholders' willingness to participate in the business, such as customer's willingness to repeat their business transactions. During PPPs, a major task in the project procurement is to attract private sector entities (e.g., banks, facility management organizations, and constructors) to join infrastructure development. Hence, their willingness to participate is undeniably a factor that can determine whether the public client can select an appropriate concessionaire and set up a robust finance structure. More importantly, the final objective of any PPP is to provide potential users with a good public service (or services) and therefore encouraging the users to use the asset ($CI_{F5\text{-}13}$) is also essential.

Conclusion

Performance evaluation of PPPs has received limited attention, particularly from a dynamic life-cycle perspective. With this in mind, a dynamic life-cycle performance measurement framework has been conceptualized for PPP infrastructure projects. This framework consists of a set of phase-based core indicators under the five measurement facets of the performance prism. Owing to the phase-based feature, the identified core indicators of the proposed PMS are capable to capture the dynamic nature of PPP infrastructure projects.

By using the performance prism, the public sector and private investors who embark on PPP infrastructure projects are provided with an insight into the comprehensive evaluation of PPPs. The proposed conceptual model is a practical tool for PPP project managers and evaluation practitioners to monitor and improve project performance while the project is still being undertaken. In essence, the PMS that has been developed offers the impetus for real-time performance control, and the improved service quality.

The paper conducted an in depth review of PPP performance measurement and proposed a conceptual framework, based on the theoretical lens of the performance prism, to examine their effectiveness and efficiency over the project life-cycle. The validation of the proposed PMS has not been presented in this paper, though ongoing research is currently in the process of testing and validating the developed framework as well as its relevant core indicators by using case studies and a range of questionnaire surveys. The case studies in future research will be on the basis of two representative social infrastructure PPP projects in Western Australia (e.g., hospital and car park) and focus on investigating and observing the whole development processes (life-cycles) of the projects. Further, a test of the importance and effectiveness of the developed "learning mechanisms" will be undertaken and presented for the purpose of comprehensively validating the practicability of the proposed framework.

Appendix. Core Indicators (CIs) of the Performance Prism under PPPs

	Phases		
Constructs	Initiation and planning (P1)	Procurement (P2)	Partnership (P3) (construction, operation & maintenance)
Stakeholder satisfaction (F1)	$CI_{F1\text{-}1}$: Public client's satisfaction $CI_{F1\text{-}2}$: Employees' satisfaction	$CI_{F1\text{-}3}$: Public client's satisfaction $CI_{F1\text{-}4}$: Employees' satisfaction	$CI_{F1\text{-}5}$: Public client's satisfaction $CI_{F1\text{-}6}$: Employees' satisfaction $CI_{F1\text{-}7}$: General concession contractor's satisfaction $CI_{F1\text{-}8}$: Subcontractors' satisfaction $CI_{F1\text{-}9}$: Suppliers' satisfaction $CI_{F1\text{-}10}$: Shareholders' satisfaction $CI_{F1\text{-}11}$: Creditors' satisfaction $CI_{F1\text{-}12}$: End-users' satisfaction
Strategies (F2)	$CI_{F2\text{-}1}$: Value for money (V*f*M) (optimum combination among life-cycle cost, physical & service quality of the asset, and the users' satisfaction)		
Processes (F3)	$CI_{F3\text{-}1}$: Comprehensiveness of environment analysis (political, economic, social & legal) $CI_{F3\text{-}2}$: Appropriateness of definition on service need & desired outputs $CI_{F3\text{-}3}$: Effectiveness of risk management (identification, analysis & allocation) $CI_{F3\text{-}4}$: Comprehensiveness of feasibility study (financing, technical & engineering) $CI_{F3\text{-}5}$: Appropriateness of financing option $CI_{F3\text{-}6}$: Appropriateness of concessionaire selection criteria $CI_{F3\text{-}7}$: Appropriateness of concession period $CI_{F3\text{-}8}$: Appropriateness of legal, commercial, technical & engineering structure $CI_{F3\text{-}9}$: Effectiveness of interface management	$CI_{F3\text{-}10}$: Transparency & competitiveness of bidding $CI_{F3\text{-}11}$: Comprehensiveness of final negotiation framework $CI_{F3\text{-}12}$: Effectiveness & efficiency of financial close $CI_{F3\text{-}13}$: Effectiveness of interface management	$CI_{F3\text{-}14}$: Compliance of legal & regulatory framework $CI_{F3\text{-}15}$: TCQ & material management $CI_{F3\text{-}16}$: Health, safety & environmental impact $CI_{F3\text{-}17}$: Effectiveness of contract management $CI_{F3\text{-}18}$: Effectiveness of dispute solution $CI_{F3\text{-}19}$: Profit & Profitability $CI_{F3\text{-}20}$: Effectiveness of operations management $CI_{F3\text{-}21}$: Effectiveness of facility management $CI_{F3\text{-}22}$: Effectiveness of interface management

Appendix (*Continued.*)

Constructs	Phases		
	Initiation and planning (P1)	Procurement (P2)	Partnership (P3) (construction, operation & maintenance)
Capabilities (F4)	CI_{F4-1}: Skilled employees CI_{F4-2}: Training & learning system CI_{F4-3}: Innovation for strategic planning & process design CI_{F4-4}: Innovation for financing	CI_{F4-5}: Skilled employees CI_{F4-6}: Training & learning system CI_{F4-7}: Innovation for procurement CI_{F4-8}: Governance	CI_{F4-9}: Skilled employees CI_{F4-10}: Training & learning system CI_{F4-11}: Finance infrastructure CI_{F4-12}: Governance CI_{F4-13}: Advanced technologies & equipment CI_{F4-14}: Innovation for technology CI_{F4-15}: Technology transfer ability
Stakeholder Contribution (F5)	CI_{F5-1}: Public client's performance in the establishment of investment environment CI_{F5-2}: Public client's performance in the establishment of legal framework CI_{F5-3}: Employees' performance	CI_{F5-4}: Public client contribution to concessionaire selection CI_{F5-5}: Employees' performance CI_{F5-6}: Private contractors' willingness to participation CI_{F5-7}: Shareholders' willingness to participation CI_{F5-8}: Creditors' willingness to participation	CI_{F5-9}: Public client willingness to active involvement CI_{F5-10}: Employees' performance CI_{F5-11}: Subcontractors' performance CI_{F5-12}: Suppliers' performance CI_{F5-13}: Users' willingness to the infrastructure use

References

Abdel Azziz, A. M. (2007). "Successful delivery of public-private partnerships for infrastructure development." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2007)133:12(918), 918–931.

Ahadzi, M., and Bowles, G. (2001). "The private finance initiative: The procurement process in perspective." *Proc., 17th ARCOM Annual Conf.*, A. Akintoye, ed., Vol. 1, Univ. of Salford, Association of Researchers in Construction Management, 991–999.

Akintoye, A., Hardcastle, C., Beck, M., Chinyio, E., and Asenova, D. (2003). "Achieving best value in private finance initiative project procurement." *Constr. Manage. Econ.*, 21(5), 461–470.

Alarcon, L. F., and Ashley, D. B. (1996). "Modelling project performance for decision making." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(1996)122:3(265), 265–273.

Allen Consulting Group. (2007). "Performance of PPPs and traditional procurement in Australia." *Final Rep. to Infrastructure Partnerships Australia*, Sydney, Australia.

Amos, P. (2004). "Public and private sector roles in the supply of transport infrastructure and services." *Operational guidance for the world bank staff, transport paper—1*, The World Bank, Washington, DC.

Anastasopoulos, P., Florax, R., Labi, S., and Karlaftis, M. (2010a). "Contracting in highway maintenance and rehabilitation: are spatial effects important?" *Transp. Res. Pol. Pract.*, 44(3), 136–146.

Anastasopoulos, P., Haddock, J., and Peeta, S. (2013a). "On improving system wide sustainability in pavement preservation programming." *J. Transp. Eng.*, 10.1061/(ASCE)TE.1943-5436.0000625, 04013012.

Anastasopoulos, P., Islam, M., Volovski, M., Powell, J., and Labi, S. (2011). "Comparative evaluation of public-private partnerships in roadway preservation." *Transportation Research Record 2235*, Transportation Research Board, Washington, DC, 9–19.

Anastasopoulos, P., Labi, S., and McCullouch, B. (2009). "Analyzing duration and prolongation of performance-based contracts using hazard-based duration and zero-inflated random parameters poisson models." *Transportation Research Record 2136*, Transportation Research Board, Washington, DC, 11–19.

Anastasopoulos, P., Labi, S., McCullouch, B., Karlaftis, M., and Moavenzadeh, F. (2010b). "Influence of highway project characteristics on contract type selection: empirical assessment." *J. Infrastruct. Syst.*, 10.1061/(ASCE)IS.1943-555X.0000035, 323–333.

Anastasopoulos, P., McCullouch, B., Gkrita, K., Mannering, F., and Sinha, K. C. (2010c). "Cost savings analysis of performance-based contracts for highway maintenance operations." *J. Infrastruct. Syst.*, 10.1061/(ASCE)IS.1943-555X.0000012, 251–263.

Anastasopoulos, P., Volovski, M., and Labi, S. (2013b). "Preservation: Are 'public private partnerships' cutting costs?" *Pavement Preserv. J.*, 6(3), 33–35.

Arditi, D., and Yasamis, F. (1998). "Incentive/disincentive contracts: Perceptions of owner and contractors." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(1998)124:5(361), 361–373.

Arthur Anderson Enterprise LSE. (2000). *Value for money drivers in the private finance initiative*, Treasury Taskforce, London.

Asian Development Bank. (2008). *Public-private partnership handbook*, Manila, Philippines.

Badshah, A. (1998). *Good governance for environmental sustainability*, United Nations Development, New York.

Bassioni, H. A., Price, A. D. F., and Hassan, T. M. (2004). "Performance measurement in construction." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2004)20:2(42), 42–50.

Bassioni, H. A., Price, A. D. F., and Hassan, T. M. (2005). "Building a conceptual framework for measuring business performance in construction: An empirical study." *Constr. Manage. Econ.*, 23(5), 495–507.

Beatham, S., Anumba, C., Thorpe, T., and Hedges, I. (2004). "KPIs: A critical appraisal of their use in construction." *Benchmarking Int. J.*, 11(1), 93–117.

Bititchi, U. M., Carrie, A. S., and McDevitt, L. (1997). "Integrated performance measurement systems: an audit and development guide." *TQM Mag.*, 9(1), 46–53.

Blanc-Brude, F., Goldsmith, H., and Valila, T. (2006). "Ex ante construction cost in the European road sector: A comparison of public-private partnerships and traditional public procurement." *Economic and Financial Rep. 2006/07*, European Investment Bank, Luxembourg.

Bourne, M., Franco, M., and Wilkes, J. (2003). "Corporate performance management." *Measur. Bus. Excellence*, 7(3), 15–21.

Buckler, B. (1996). "A learning process model to achieve continuous improvement and innovation." *Learn. Org.*, 3(3), 31–39.

Carrillo, P. M., Robinson, H. S., Anumba, C. J., and Bouchlaghem, N. M. (2006). "A knowledge transfer framework: The PFI context." *Constr. Manage. Econ.*, 24(10), 1045–1056.

Chan, A. P. C., and Chan, A. P. L. (2004). "Key performance indicators for measuring construction success." *Benchmarking Int. J.*, 11(2), 203–221.

Chan, A. P. C., Yeung, J. F. Y., Yu, C. C. P., Wang, S. Q., and Ke, Y. (2011). "Empirical study of risk assessment and allocation of public-private partnership projects in China." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000049, 136–148.

Chan, T. K. (2009). "Measuring performance of the Malaysian construction industry." *Constr. Manage. Econ.*, 27(12), 1231–1244.
Chan, W. T., Chen, C., Messner, J. I., and Chua, D. K. H. (2005). "Interface management for China's build-operate-transfer projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2005)131:6(645), 645–655.
Charoenpornpattana, S., and Minato, T. (1999). "Privatization-induced risks: State-owned transportation enterprises in Thailand." *Proc., Joint CIB Symp. on Profitable Partnering in Construction Procurement*, E & Fn Spon, London, 429–439.
Chinyio, E., and Gameson, R. (2009). "Private finance initiative in use." *Policy, finance & management for public-private partnerships*, A. Akintoye and M. Beck, eds., Wiley-Blackwell, Oxford, U.K, 3–23.
Cox, R. F., Issa, R. R. A., and Ahrens, D. (2003). "Management's perception of key performance indicators for construction." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2003)129:2(142), 142–151.
Davis, P. R., and Love, P. E. D. (2011). "Alliance contracting: Adding value through relationship development." *Eng. Constr. Archit. Manage.*, 18(5), 444–461.
del-Rey-Chamorro, F. M., Roy, R., Wegen, B. V., and Steele, A. (2003). "A framework to create key performance indicators for knowledge management solutions." *J. Knowl. Manage.*, 7(2), 46–62.
Denton, J. (1998). *Organisational learning and effectiveness*, Routledge, New York.
Department of Transport. (2002). "Public sector comparators factsheet." ⟨http://www.railways.dtlr.gov.uk⟩ (Aug. 2, 2012).
Department of Treasury and Finance. (2007). "Facts and fictions about public private partnerships." ⟨http://www.partnerships.vic.gov.au⟩ (Oct. 23, 2012).
Devapriya, K. A. K. (2006). "Governance issues in financing of public private partnership organizations in network infrastructure industries." *Int. J. Proj. Manage.*, 24(7) 557–565.
European Investment Bank (EIB). (2004). "The EIB's role in public-private partnerships (PPPs)." Luxembourg, Belgium.
European Investment Bank (EIB). (2012). "The guide to guidance: How to prepare, procure and deliver PPP projects." Luxembourg, Belgium.
El-Gohary, N. M., Osman, H., and El-Diraby, T. E. (2006). "Stakeholder management for public private partnerships." *Int. J. Proj. Manage.*, 24(7), 595–604.
Elyamany, A., Basha, I., and Zayed, T. (2007). "Performance evaluation model for construction companies." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2007)133:8(574), 574–581.
European Commission. (2003). "Guidelines for successful public-private partnerships." Brussels, Belgium.
Farbey, B., Land, F., and Targett, D. (1992). "Evaluating IT investments." *J. Inform. Technol.*, 7(2), 109–122.
Fitzgerald, P. (2004). "Review of partnerships Victoria provided infrastructure." *Final Rep. to the Treasurer*, Growth Solutions, Melbourne, Australia.
Grimsey, D., and Lewis, M. K. (2002). "Evaluating the risks of public private partnerships for infrastructure projects." *Int. J. Proj. Manage.*, 20(2), 107–118.
Grimsey, D., and Lewis, M. K. (2004). *Public private partnerships: The worldwide revolution in infrastructure provision and project finance*, Edward Elgar, Cheltenham, U.K.
Grimsey, D., and Lewis, M. K. (2005). "Are public private partnerships value for money?" *Accounting Forum*, 29(4), 345–378.
Haponava, T., and Al-Jibouri, S. (2010). "Influence of process performance during the construction stage in achieving end-project goals." *Constr. Manage. Econ.*, 28(8), 853–869.
Haponava, T., and Al-Jibouri, S. (2012). "Proposed system for measuring project performance using process-based key performance indicators." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000078, 140–149.
Haskins, S., Gale, D., and Kelly, L. (2002). "Creating and optimizing new forms of public-private partnerships in Seattle." *Water Sci. Technol. Water Supply*, 2(4), 211–218.
Henjewele, C., Sun, M., and Fewings, P. (2011). "Critical parameters influencing value for money variations in PFI projects in the healthcare and transport sectors." *Constr. Manage. Econ.*, 29(8), 825–839.
Herbsman, Z. J., and Glagola, C. R. (1998). "Lane rental—Innovative way to reduce road construction time." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(1998)124:5(411), 411–417.
Hodge, G. A. (2004). "The risky business of public-private partnerships." *Australian J. Public Admin.*, 63(4), 37–49.
Hodge, G. A. (2005). "Public private partnerships: the Australasian experience with physical infrastructure." *The challenge of public-private partnerships: Learning from international experience*, G. A. Hodge and C. Greve, eds., Edward Elgar, Cheltenham, U.K., 305–331.
Hodge, G. A., and Greve, C. (2007). "Public-private partnerships: an international performance review." *Public Admin. Rev.*, 67(3), 545–558.
House of Commons. (2003). *The operational performance of PFI prisons*, House of Commons, London.
Hwang, B. G., Thomas, S. R., and Caldas, C. H. (2010). "Performance metric development for pharmaceutical construction projects." *Int. J. Proj. Manage.*, 28(3), 265–274.
Idrus, A., Sodangi, M., and Husin, M. H. (2011). "Priorizing project performance criteria within client perspective." *Res. J. Appl. Sci. Eng. Technol.*, 3(10), 1142–1151.
Irani, Z., Sharif, A., and Love, P. E. D. (2001). "Transforming failure into success through organizational learning: An analysis of a manufacturing information system." *Eur. J. Inform. Syst.*, 10(1), 55–66.
Irani, Z., Sharif, A., and Love, P. E. D. (2005). "Linking knowledge transformation to information systems evaluation." *Eur. J. Inform. Syst.*, 14(3), 213–218.
Jefferies, M. (2006). "Critical success factors of public private sector partnerships: a case study on the Sydney SuperDome." *Eng. Constr. Archit. Manage.*, 13(5), 451–462.
Jefferies, M., Gameson, R., and Rowlinson, S. (2002). "Critical success factors of the BOOT procurement system: Reflection from the stadium Australia case study." *Eng. Constr. Archit. Manage.*, 9(4), 352–361.
Jin, X. H. (2010). "Determinants of efficient risk allocation in privately financed public infrastructure projects in Australia." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000118, 138–150.
Jin, X. H. (2011). "Model for efficient risk allocation in privately financed public infrastructure projects using neuro-fuzzy techniques." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000365, 1003–1014.
Kagioglou, M., Cooper, R., and Aouad, G. (2001). "Performance management in construction: A conceptual model." *Constr. Manage. Econ.*, 19(1), 85–95.
Kennerley, M., and Neely, A. (2003). "Measuring performance in a changing business environment." *Int. J. Oper. Prod. Manage.*, 23(2), 213–229.
Koch, C., and Buser, M. (2006). "Emerging metagovernance as an institutional framework for public private partnership networks in Denmark." *Int. J. Proj. Manage.*, 24(7), 548–556.
Koppenjan, J. F. M. (2005). "The formation of public-private partnerships: lessons from nine transport infrastructure projects in the Netherlands." *Publ. Admin.*, 83(1), 135–157.
Kululanga, G. K., Edum-Fotwe, F., and McCaffer, R. (2001). "Measuring construction contractors organisational learning." *Build. Res. Inf.*, 29(1), 21–29.
Kumaraswamy, M. M., and Anvuur, A. M. (2008). "Selecting sustainable teams for PPP projects." *Build. Environ.*, 43(6), 999–1009.
Kumaraswamy, M. M., and Thorpe, A. (1996). "Systematizing construction project evaluation." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(1996)12:1(34), 34–39.
Kumaraswamy, M. M., and Zhang, X. Q. (2001). "Governmental role in BOT-led infrastructure development." *Int. J. Proj. Manage.*, 19(4), 195–205.
Kwak, Y. H., Chih, Y. Y., and Ibbs, C. W. (2009). "Towards a comprehensive understanding of public private partnerships for infrastructure development." *California Manage. Rev.*, 51(2), 52–78.
Lai, I. K. W., and Lam, F. K. S. (2010). "Perception of various performance criteria by stakeholders in the construction sector in Hong Kong." *Constr. Manage. Econ.*, 28(4), 377–391.
Lebas, M. J. (1995). "Performance measurement and performance management." *Int. J. Prod. Econ.*, 41(1–3), 23–35.
Levy, S. M. (1996). *Build, operate, transfer: Paving the way for tomorrow's infrastructure*, Wiley, New York.

Li, B., Akintoye, A., Edwards, P. J., and Hardcastle, C. (2005a). "Critical success factors for PPP/PFI projects in the UK construction industry." *Constr. Manage. Econ.*, 23(5), 459–471.
Li, B., Akintoye, A., Edwards, P. J., and Hardcastle, C. (2005b). "The allocation of risk in PPP/PFI construction project in the UK." *Int. J. Proj. Manage.*, 23(1), 25–35.
Liautaud, G. (2004). *Maintaining roads: experience with output-based contracts in Argentina*, The World Bank, Washington, DC.
Lim, C. S., and Mohamed, M. Z. (1999). "Criteria of project success: an exploratory re-examination." *Int. J. Proj. Manage.*, 17(4), 243–248.
Liu, J., Love, P. E. D., Davis, P. R., Smith, J., and Regan, M. (2013). "Performance measurement framework in PPP projects." *Proc., Int. Conf. on PPP Body of Knowledge (CIB TG72)*, A. Akintoye, C. Liyanage, and J. Goulding, eds., Univ. of Central Lancashire, Preston, U.K., 55–64.
Love, P. E. D., and Holt, G. (2000). "Construction business performance measurement: The SPM alternative." *Bus. Process Manage. J.*, 6(5), 408–416.
Love, P. E. D., Huang, J. C., Edwards, D. J., and Irani, Z. (2004). "Nurturing a learning organization in construction: A focus on strategic shift, organizational transformation, customer orientation and quality centered learning." *Constr. Innov.*, 4(2), 113–126.
Love, P. E. D., Irani, Z., and Edwards, D. (2003). "Learning to reduce rework in projects: Analysis of firms learning and quality practices." *Proj. Manage. J.*, 34(3), 13–25.
Luu, V. T., Kim, S. Y., Cao, H. L., and Park, Y. M. (2008a). "Performance measurement of construction firms in developing countries." *Constr. Manage. Econ.*, 26(4), 373–386.
Luu, V. T., Kim, S. Y., and Huynh, T. A. (2008b). "Improving project management performance of large contractors using benchmarking approach." *Int. J. Proj. Manage.*, 26(7), 758–769.
Merna, T., and Dubey, R. (1998). *Financial engineering in the procurement of projects*, Asia Law and Practice, Hong Kong.
Mooraj, S., Oyon, D., and Hostettler, D. (1999). "The Balanced Scorecard: a necessary good or an unnecessary evil." *Eur. Manage. J.*, 17(5), 481–491.
Mott MacDonald. (2002). "Review of large public procurement in the UK." *Rep. to HM Treasury*, London.
National Audit Office (NAO). (2000). "Examining the value for money of deals under the private finance initiative." The Stationery Office, London.
National Audit Office (NAO). (2001). "Managing the relationship to secure a successful partnership in PFI projects." The Stationery Office, London.
National Audit Office (NAO). (2003). "PFI: construction performance." *Rep. by the Comptroller and Auditor General, HC 371, Session 2002-03*, London.
Neely, A. (1999). "The performance measurement revolution: Why now and what next?" *Int. J. Oper. Prod. Manage.*, 19(2), 205–228.
Neely, A., Adams, C., and Crowe, P. (2001). "The performance prism in practice." *Measur. Bus. Excellence*, 5(2), 6–12.
Neely, A., Adams, C., and Kennerley, M. (2002). *The performance prism: The scorecard for measuring and managing business success*, Prentice Hall Financial Times, London.
Neely, A., Gregory, M., and Platts, K. (2005). "Performance measurement system design: A literature review and research agenda." *Int. J. Oper. Prod. Manage.*, 25(12), 1228–1263.
Nisar, T. M. (2007). "Risk management in public-private partnerships contracts." *Publ. Org. Rev.*, 7(1), 1–19.
NSW Auditor-General. (2006). "The new schools privately financed project." *Auditor-General's Rep. on Performance Audit*, Sydney, Australia.
Office of Government Commerce. (2002). "Green public private partnerships." Norwich, U.K.
Pakkala, P. (2002). *Innovative project delivery methods for infrastructure*, Finnish Road Enterprise, Helsinki, Finland.
Partnerships Victoria. (2001). "Public sector comparator: A technical note." ⟨http://www.partnerships.vic.gov.au⟩ (Oct. 23, 2012).
Pedler, M., Burgoyne, J., and Boydell, T. (1991). *The learning company*, McGraw-Hill, London.
Pongsiri, N. (2002). "Regulations and public-private partnerships." *Int. J. Publ. Sector Manage.*, 15(6), 487–495.
Qiao, L., Wang, S. Q., Tiong, R. L. K., and Chan, T. S. (2001). "Framework for critical success factors of BOT project in China." *J. Proj. Finance*, 7(1), 53–61.
Qureshi, T. M., Warraich, A. S., and Hijazi, S. T. (2009). "Significance of project management performance assessment (PMPA) model." *Int. J. Proj. Manage.*, 27(4), 378–388.
Raisbeck, P., Duffield, C., and Xu, M. (2010). "Comparative performance of PPPs and traditional procurement in Australia." *Constr. Manage. Econ.*, 28(4), 345–359.
Regan, M., Smith, J., and Love, P. E. D. (2011a). "Impact of the capital market collapse on public-private partnership infrastructure projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000245, 6–16.
Regan, M., Smith, J., and Love, P. E. D. (2011b). "Infrastructure procurement: Learning from private-public experiences 'down under." *Environ. Plann. C Gov. Pol.*, 29(2), 363–378.
Robinson, H. S., and Scott, J. (2009). "Service delivery and performance monitoring in PPP/PFI projects." *Constr. Manage. Econ.*, 27(2), 181–197.
Rockart, J. F. (1982). "The changing role of the information system executive: A critical success factors perspective." *MIT Sloan Manage. Rev.*, 24(1), 3–13.
Roth, L. (2004). "Privatisation of prisons." *Background Paper No. 3/04*, New South Wales Parliament, Sydney, Australia.
Sachs, T., Elbing, C., Tiong, R. L. K., and Alfen, H. (2005). "Efficient assessment of value for money (VFM) for selecting effective public private partnership (PPP) solutions—A comparative study of VFM assessment for PPPs in Singapore and Germany." School for Civil and Environmental Engineering, Nanyang Technological Univ., Singapore.
Sachs, T., Tiong, R. L. K., and Wang, S. Q. (2007). "Analysis of political risks and opportunities in public private partnerships (PPPs) in China and selected Asian countries." *Chinese Manage. Stud.*, 1(2), 126–148.
Salman, A. F. M., Skiboniewski, M. J., and Basha, I. (2007). "BOT viability model for large-sale infrastructure projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2007)133:1(50), 50–63.
Scarbrough, H., Swan, J., and Preston, J. (1998). "Knowledge management: A literature review." Institute of Personnel and Development, London.
Schaufelberger, J. E., and Wipadapisutand, I. (2003). "Alternate financing strategies for build-operate-transfer projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2003)129:2(205), 205–213.
Shen, L. Y., Li, Q. M., Drew, D., and Shen, Q. P. (2004). "Awarding construction contracts on multicriteria basis in China." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2004)130:3(385), 385–393.
Sidwell, A. C. (1990). "Project management: Dynamics and performance." *Constr. Manage. Econ.*, 8(2), 159–178.
Sing, C. P., Love, P. E. D., Smith, J., and Tam, C. M. (2013). "Factors influencing final account settlement in construction projects." *Proc., RICS COBRA 2013*, Royal Institution of Chartered Surveyors, New Delhi, India.
Singh, P., Oh, J. E., Labi, S., and Sinha, K. C. (2007). "Cost-effectiveness evaluation of warranty pavement projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2007)133:3(217), 217–244.
Smith, H., and Fingar, P. (2003). "Business process management: The third wave." Meghan-Kiffer Press, Tampa, FL.
Sohail, M., and Baldwin, A. N. (2004). "Performance indicators for 'micro-projects' in developing countries." *Constr. Manage. Econ.*, 22(1), 11–23.
Solomon, P. J., and Young, R. R. (2007). *Performance-based earned value*, Wiley, Hoboken, NJ.
Songer, A. D., and Molenaar, K. R. (1997). "Appropriate project characteristics for public sector design-build projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(1997)123:1(34), 34–40.
Stankevich, N., Qureshi, N., and Queiroz, C. (2005). "Performance-based contracting for preservation and improvement of road assets." *Transport Note TN-27*, World Bank, Washington, DC.
Tam, C. M., and Leung, A. W. T. (1997). "Risk management of BOT projects in Southeast Asian countries." *Proc., CIB W92 and CIB TG23*

Joint Symp.: Profitable Partnering in Construction Procurement, S. Ogunlana, ed., E & Fin Spon, London.
Thomas, A. V., Kalidindi, S. N., and Ananthanarayanan, K. (2003). "Risk perception analysis of BOT road project participants in India." *Constr. Manage. Econ.*, 21(4), 393–407.
Tiong, R. L. K. (1996). "CSFs in competitive tendering and negotiation model for BOT projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(1996)122:3(205), 205–211.
Treasury Taskforce. (1998). "Partnerships for prosperity—The Private Finance Initiative." HM Treasury, London, ⟨http://products.ihs.com/cis/Doc.aspx?AuthCode&DocNum=248093⟩.
Treasury Taskforce. (1999). "Step-by-step guide to the PFI procurement process." ⟨http://www.treasury-projects.gov.uk⟩ (Aug. 8, 2012).
VAGO. (2002). "Report on public sector agencies." Victorian Auditor-General's Office, Melbourne, Australia.
Wang, C. L., and Ahmed, P. K. (2003). "Organisational learning: A critical review." *Learn. Org.*, 10(1), 8–17.
Wang, S. Q., Tiong, R. L. K., Ting, S. K., and Ashley, D. (2000a). "Evaluation and management of foreign exchange and revenue risks in China's BOT projects." *Constr. Manage. Econ.*, 18(2), 197–207.
Wang, S. Q., Tiong, R. L. K., Ting, S. K., and Ashley, D. (2000b). "Evaluation and management of political risks in China's BOT projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2000)126:3(242), 242–250.
Washington State Department of Transportation (WSDOT). (2013). "Mega project assessment." Olympia.
Xenidis, Y., and Angelides, D. (2005a). "The financial risks in build-operate-transfer projects." *Constr. Manage. Econ.*, 23(4), 431–441.
Xenidis, Y., and Angelides, D. (2005b). "The legal risks in build-operate-transfer projects." *J. Constr. Res.*, 273–292.
Xu, Y., Chan, A. P. C., and Yeung, J. F. Y. (2010). "Developing a fuzzy risk allocation model for PPP projects in China." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000189, 894–903.
Ye, S., and Tiong, R. K. L. (2000). "Government support and risk-return trade-off in China's BOT power projects." *Eng. Constr. Archit. Manage.*, 7(4), 412–422.
Yong, H. K. (2010). *Public-private partnerships policy and practice*, Commonwealth Secretariat, London.
Yuan, J., Zeng, A. Y., Skibniewski, M. J., and Li, Q. (2009). "Selection of performance objectives and key performance indicators in public-private partnership projects to achieve value for money." *Constr. Manage. Econ.*, 27(3), 253–270.
Zhang, X. Q. (2004a). "Concessionaire selection: Methods and criteria." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2004)130:2(235), 235–244.
Zhang, X. Q. (2004b). "Improving concessionaire selection protocols in public/private partnered infrastructure projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2004)130:5(670), 670–679.
Zhang, X. Q. (2005a). "Criteria for selecting the private-sector partner in public-private partnerships." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2005)131:6(631), 631–644.
Zhang, X. Q. (2005b). "Critical success factors for public-private partnerships in infrastructure development." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2005)131:1(3), 3–14.
Zhang, X. Q. (2005c). "Financial viability analysis and capital structure optimization in privatized public infrastructure projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2005)131:6(656), 656–668.
Zhang, X. Q. (2006a). "Factor analysis of public clients' best value objective in public-privately partnered infrastructure projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2006)132:9(956), 956–965.
Zhang, X. Q. (2006b). "Public clients' best value perspectives of public private partnerships in infrastructure development." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2006)132:2(107), 107–114.
Zhang, X. Q., and Kumaraswamy, M. M. (2001). "Hong Kong experience in managing BOT projects." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2001)127:2(154), 154–162.
Zhang, X. Q., Kumaraswamy, M. M., Zheng, W., and Palaneeswaran, E. (2002). "Concessionaire selection for build-operate-transfer tunnel projects in Hong Kong." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2002)128:2(155), 155–163.
Zheng, J., Roehrich, J. K., and Lewis, M. A. (2008). "The dynamics of contractual and relational governance: evidence from long-term public-private procurement arrangements." *J. Purch. Supply Manage.*, 14(1), 43–54.
Zietlow, G. (2004). "Implementing performance-based road management and maintenance contracts in developing countries—An instrument of German technical cooperation." German Development Cooperation (GTZ), Eschborn, Germany.
Zietlow, G. (2005). "Cutting costs and improving quality through performance-based road management and maintenance contracts—The Latin American and OECD experience." Univ. of Birmingham, Birmingham, U.K.