Praxis of Performance Measurement in Public-Private Partnerships: Moving beyond the Iron Triangle

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Abstract: An effective and efficient performance measurement is deemed to be pivotal for ensuring owners' and stakeholders' needs are being met throughout a project's lifecycle. To determine the nature of performance measurement in Australian public-private partnerships (PPPs), an interpretivist approach that utilized semistructured interviews was undertaken in the State of Western Australia. A total of 25 interviews were conducted with key stakeholders and it was revealed that there was a proclivity for performance measurements during design and construction to focus on traditional ex ante and ex post evaluations that were aligned to the conventional iron triangle: time, cost, and quality (TCQ). However, there was widespread consensus among the interviewees that the traditional TCQ approach was too simplistic to capture the inherent complexities associated with social infrastructure PPPs. In addressing this issue the analysis indicates that process-based lifecycle performance measurement that strategically places an emphasis on value for money (VfM) should be introduced into PPPs to replace traditional ex ante and ex post evaluations. It is suggested that this type of measurement can be integrated with a broader VfM assessment and a series of key performance indicators to enable the public and private sectors to improve their performance throughout a project's lifecycle. The empirical analysis provides the foundations for developing a performance measurement that can ensure assets are future proofed over their lifecycles. **DOI: 10.1061/(ASCE)ME.1943-5479.0000433.** *© 2016 American Society of Civil Engineers.*

Author keywords: Public-private partnerships (PPPs); Performance measurement; Lifecycle; Social infrastructure; Western Australia.

Introduction

Public-private partnerships (PPPs) have been acknowledged as being a cost-effective and efficient method for procuring public assets. Over the last decade, they have become increasingly popular throughout world economies for delivering critical economic and social infrastructure (e.g., healthcare, education, and recreation), especially for governments with limited funding available to them (Yong 2010). Despite their increasing use and importance in meeting society's needs, there have been a considerable number of issues surrounding the utilization of PPPs. In Australia, for example, there is a proclivity for cost and time overruns during construction (Raisbeck et al. 2010). However, studies have revealed that the project delivery mechanism adopted does not influence their occurrence (Love 2002; Love et al. 2009, 2012). Fundamentally, cost and time overruns are an innate feature of infrastructure projects regardless of how they are procured (Love et al. 2015).

A plethora of factors can contribute to the successful delivery of a PPP project (Osei-Kyei and Chan 2015; Liu et al. 2015a), in which an effective and comprehensive performance evaluation plays a decisive role in ensuring such an outcome is achieved (Yuan et al. 2009; Liu et al. 2015b, c). According to Yuan et al. (2009) ineffective performance measurement (PM) of PPPs can contribute to suboptimal service quality. Essentially, PM plays a decisive role in business success, regardless of corporate or project level (Love and Holt 2000; Kagioglou et al. 2001; Bassioni et al. 2004).

The PPP market in Australia is considered to be mature and sophisticated (Hodge 2004). Incomplete and ineffective performance evaluation, however, has been consistently identified as a significant factor contributing to social infrastructure PPP projects experiencing difficulties during construction and operation, for example, the Latrobe Regional Hospital and Deer Park Women's Prison in Victoria, Australia, both of which were associated with inefficient delivery, inadequate professional staff in the operations stages, and poor service quality (House of Commons 2003; Roth 2004; Harris et al. 2014). Hodge (2005) and Regan et al. (2011b) have argued that most PPPs have not undergone a comprehensive ex post evaluation in terms of what was delivered. In fact, evaluating performance is one of the core activities in contract management of PPPs (Chinyio and Gameson 2009). Nonetheless, research examining the nature of PPP PM, especially within the context of social infrastructure PPPs, has been limited (Kwak et al. 2009; Liu et al. 2015b). To determine the current nature of PM in Australian PPPs and provide a robust platform for their evaluation, an interpretivist approach is used to empirically solicit views and opinions from stakeholders. Such views and opinions are pivotal to developing a performance measurement system (PMS) that can enhance the governance within a PPP and therefore provide a framework that enables the best possible process for making decisions. Not only

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Note. This manuscript was submitted on June 1, 2015; approved on December 4, 2015; published online on February 22, 2016. Discussion period open until July 22, 2016; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Management in Engineering***, © ASCE, ISSN 0742-597X.

will it provide the special purpose vehicle (SPV) with improved confidence that project deliverables will be met, but it will also improve the faith that the team members have in the project and its decision-making processes.

Public-Private Partnerships

There is no universally accepted definition of PPP and its meaning varies between countries. According to the European Investment Bank (2004, p. 2), 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." Similarly, the Public-Private Infrastructure Advisory Facility (2014) defines PPPs as the contractual arrangements that incorporate "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."

Despite the inherent drawbacks associated with PPPs, governments embark on them for (1) accelerated infrastructure provision, (2) timely project implementation, (3) reduced lifecycle cost, (4) reduced government risks, (5) improved service quality, and (6) enhanced prudent management of public expenditure and reduced corruption (European Commission 2003). Compared with other forms of procurement, the defining features of PPPs encompass risk transfer, long-term contractual relationship, and partnership agreement (Akintoye et al. 2003; Zhang 2004b). Kwak et al. (2009, p. 56) elaborate with "the complexity of contractual relationships between participants, and the long concession periods associated with PPPs, makes them distinct from traditional infrastructure development routes." With these features and characteristics, there has been an inordinate amount of research that has examined PPPs, with six common themes being explicitly identified in Table 1 (Tang et al. 2010; Liu et al. 2015b).

As indicated in Table 1, the PM of PPPs has not been identified as a main research area and subsequently received limited attention in the normative literature, even though it is critical to PPPs' success (Liu et al. 2014). With this, no widely accepted performance measurement framework (PMF) has been developed for infrastructure projects (Toor and Ogunlana 2010). In essence, performance measure is "a metric used to quantify the efficiency and/or effectiveness of an action" (Neely et al. 2005, p. 1,229), for example, key performance indicators (KPIs), which are a set of measures that are indicative of the organization's performance (Beatham et al. 2004).

Over the past decade, research examining PM of PPPs has tended to focus on either reviewing what KPIs have been used in procured PPPs or quantitatively testing some new KPIs of PPPs that were derived from the literature, e.g., Garvin et al. (2011), Yuan et al. (2009), and Mladenovic et al. (2013). Such studies primarily relied on the positivist approach; therefore, they failed in empirically identifying the problems in the performance measurement of PPPs according to practitioners' perspectives (Liu et al. 2015b). Neely et al. (2005) argue that practitioners' views cannot be ignored during the process of designing a new performance measurement approach for the organization. However, there is currently a lack of studies conducted to essentially address this critical issue in investigating PPP evaluation. Therefore, the aim of this paper is to fill this knowledge gap by empirically proposing a PMF within the context of social infrastructure PPP projects.

Research Methodology

Justification of Research Approach

Empiricism refers to the philosophical belief that sensory experience is the primary source of knowledge. According to Love et al. (2002, p. 294), "research in construction management can be categorised as at the intersection of natural science and social science." While natural science investigates events that are comprised of a variety of facts independent from people's thinking, social science concentrates on studying participants (i.e., key stakeholders in projects). Accordingly, two methodologies have tended to dominate research in construction management: the positivist and interpretivist approaches. However, this is in spite of Love et al. (2002) and Sage et al. (2014) suggesting the need for methodological pluralism to advance the scope of theory in construction and engineering management.

Research on PM has tended to marry with the ontology and epistemology of interpretivism as reality and multiple perspectives are sought to gain an understanding of this use in practice (Neely et al. 2000, 2005). In this instance, the knowledge that will be gathered will be "socially constructed rather than objectively determined" (Carson et al. 2001, p. 5). As a result, the interpretivist research adopted focused on understanding and interpreting and consists of a structure that is personally and flexibly receptive to deriving meanings from the interactions undertaken with participants (Black 2006). Taking this approach ensured that the perceptions and viewpoints of senior management personnel, which are critical to the success or failure of the organizations' PMSs, were obtained (Bourne et al. 2002). Furthermore, Neely (1999)

Table 1. Categorization of PPP Research

Research area	Past studies of PPPs
Critical success factors (CSFs)	Tiong (1996), Qiao et al. (2001), Jefferies et al. (2002), Li et al. (2005a), Zhang (2005b), Jefferies (2006), Chan et al. (2010), Liu et al. (2015c), and Osei-Kyeiand and Chan (2015)
Roles and responsibilities of the public sector	Kumaraswamy and Zhang (2001), Hart (2003), Pongsiri (2002), Koch and Buser (2006), Abdel Aziz (2007), Warner and Hefetz (2008), and Soomro and Zhang (2013)
Concessionaire selection	Treasury Taskforce (1999), Ahadzi and Bowles (2001), Zhang and Kumaraswamy (2001), Zhang (2004a, b, 2005a), and Jang (2011)
Risk management	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), and Chan et al. (2011)
Cost and time efficiency under different types of contract	Herbsman and Glagola (1998), Zietlow (2005), Anastasopoulos et al. (2009, 2010a, b), Raisbeck et al. (2010), and Anastasopoulos et al. (2013)
Project finance	Levy (1996), Merna and Dubey (1998), Ye and Tiong (2000), Schaufelberger and Wipadapisutand (2003), Zhang (2005b), Devapriya (2006), Daube et al. (2008), Regan et al. (2011a), and Engel et al. (2013)

and Bourne et al. (2000) maintain that understanding the existing PM and interpreting what key objectives and measures should be met and used is essential to the development of an effective and efficient PMS. Hence, the interpretivist approach is appropriate for the nature of this research because an understanding of existing PPP PM is acquired so as to develop a robust system that can be form part of a project's governance.

Data Collection

Research relying on interpretivism is primarily nonquantitative. Therefore, the interviews with stakeholders who had experience with PPPs were undertaken to solicit their views and opinions about the issue of PM. According to Kumar (1989), meeting this objective requires a sample size of 15 to 35 participants purposefully selected, who have specialized knowledge in the topic. A total of 25 in-depth interviews with key stakeholders involved with the procurement of PPPs were conducted over a period of 8 months (Table 2). Interviews took 60 to 90 min with permission to digitally record them. The research was conducted in Western Australia (WA), and to date there have been no economic PPPs constructed. Thus, the research was limited to PM in social infrastructure such as hospitals, prisons, and schools.

The interviews were organized as conversations and are suitable for all stages of the research, especially for the following situations: (1) understanding the points of views of specific groups or individuals, (2) identifying directions or recommendations for programs' or projects' future development, and (3) gathering essential information for the design of a further comprehensive study (Kumar 1989). The interviewees who participated in the research had between 8 and 20 years of experience with social infrastructure PPP projects. All interviews were unstructured, but the following indicative questions provided the stimulus for dialogue:

- How are/were the performances of the PPPs that you are/were involved with evaluated?
- What do you consider to be the limitations in PPP performance measurement?
- What do you consider to be areas where performance measurement can be improved?
- What do you consider to be the main difficulties in implementing a new performance measurement in PPPs?

The interviews focused on the (1) current approaches of PM and the shortcomings, (2) direction for ameliorating PM, and (3) potential difficulties in implementing a new PM. At the beginning of each interview, the interviewee was asked to select a completed or ongoing social infrastructure PPP project with which the interviewee had been or is currently involved.

Data Analysis

The textural narratives compiled were analyzed using *NVivo 10* software, which combines the efficient management of nonnumerical, unstructured data with powerful processes of indexing and theorizing. *NVivo 10* enabled additional data sources and journal notes to be incorporated into the analysis as well as identify emergent new themes. The development and reassessment of themes as the analysis progressed accords with calls to avoid confining data to predetermined sets of categories (Silverman 2006). Kvale (1996, p. 204) suggests that ad hoc methods for generating meaning enable the researcher to access "a variety of common-sense approaches to interview text using an interplay of techniques such as noting patterns, seeing plausibility, making comparisons etc."

Table 2. Sample Information

Interviewee	Number	Serial codes
Public clients	3	PC-01 to PC-03
Project managers	3	PM-01 to PM-03
Architects or design managers	4	A/DM-01 to A/DM-04
Financial advisors	4	FA-01 to FA-04
Contract advisor	1	CA-01
Legal advisors	3	LA-01 to LA-03
Procurement advisors	3	PA-01 to PA-03
Operations managers	2	OM-01 to OM-02
Asset managers	2	AM-01 to AM-02

Research Findings

Existing Performance Measurement of PPPs

Understanding the existing approaches used to measure performance in PPPs is crucial to developing a new and effective system for performance evaluation. In addressing this issue, a project manager (PM-01) stated "The performance evaluation of our social infrastructure PPP projects before the assets' operations is similar to that of the projects procured by using traditional methods. This kind of evaluation aims to measure whether the project was delivered on time and on budget and also evaluate if the procured asset can meet the predefined quality specification."

All interviews indicated that the PM of PPPs is comprised of two parts: (1) the evaluation for design and construction, and (2) the measurement during operation. It was also made explicit by those interviewed that the design and construction of PPPs was evaluated against time, cost, and quality (TCQ), while the measurements for the assets' operational performance relied on a series of KPIs. This was emphasised by a public sector advisor (PA-02) who made the following comment:

> The performance evaluation conducted for social PPPs was divided into two parts. On the one hand, the measurements for design and construction are pretty straightforward focusing on time, cost, and quality. On the other hand, many social infrastructure PPPs are behind the availability-based or operational model, and there are KPIs (i.e., key performance indicators) associated with the assets' operations, covering a series of issues. Take a water treatment plant, for example. The KPIs will be around issues like the quality of the water in terms of whether it has bacteriological qualities, heavy metals, and the colour and smell of it. And, there are KPIs of quantity. The contract has specified the plant would have needed to be able treat so much water in a certain period of time. In summary, the KPIs are based around those two types of output parameters. If the private sector cannot meet those, they will get abated potentially.

The key emergent themes and issues arising from the interviews of the current PM being undertaken are presented in Fig. 1. While TCQ have been typically used to evaluate conventional procurement arrangements (e.g., traditional design and build forms), PPPs are more complicated due to the financial commitments of the private and public sector, stakeholder interests, and their long-term impact on taxpayers. Thus, a robust evaluation mechanism is required, which can accommodate an array of multiple views throughout the asset's lifecycle (Liu et al. 2015b). Bearing this perspective in mind, it is necessary to identify whether or not existing PM approaches (i.e., TCQ and operational KPIs) are robust and suitable for capturing the holistic performance of PPPs.

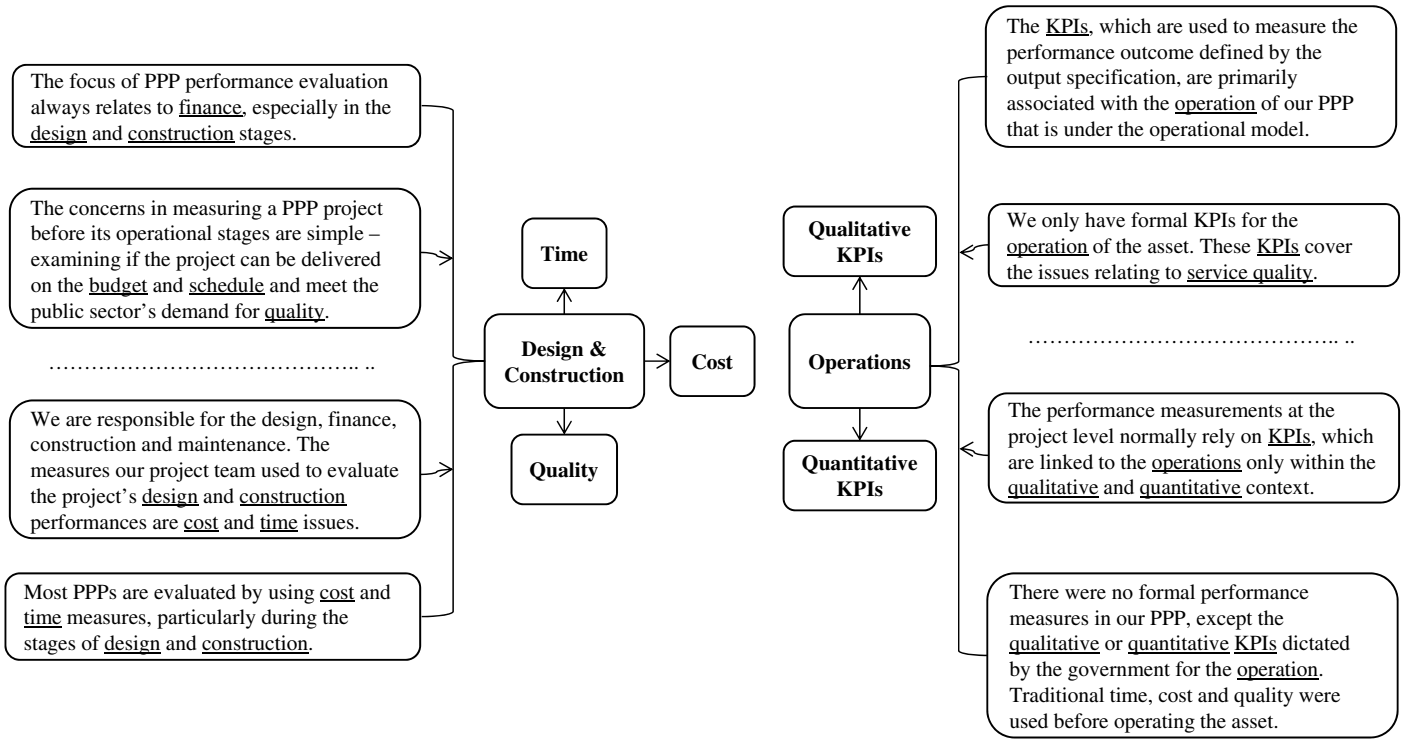

Fig. 1. Existing performance measurements of social infrastructure PPPs

Shortcomings of Existing Performance Measurement in PPPs

Based on Fig. 1, it was widely agreed that existing PM approaches being utilized within social infrastructure PPPs were myopic and that there was a lack of systematic measures designed to evaluate some critical issues of the projects' design and construction, such as innovation, asset sustainability, and stakeholder satisfaction. In particular, a project manager who had been involved with delivering three social infrastructure PPPs (PM-02) stated "The conventional method used for evaluating PPP design and construction is not sufficient … there is the lack of formal and systematic measures to evaluate if the outputs are innovative or sustainable for a long-term period, or what the key stakeholders' satisfaction levels are …"

The public sector not only relies on private entities to financially invest in infrastructure, but also draws on its expertise to engender innovation and develop a sustainable asset that is able to meet stakeholders' needs. By focusing on TCQ, there is a tendency for the long-term needs of stakeholders to be overshadowed, particularly in the case of schools or hospitals (KPMG 2008). This was acknowledged by a design manager (A/DM-01), who stated "Although delivering a PPP on time and on budget is very important, there may be a need for measures to capture some intangible factors, for example, innovation in design. This is actually what the private sector should bring to a public project; however, the approach we are using cannot reflect it."

Reflecting on the use of TCQ as a measure, a senior financial advisor (FA-03) proposed that the value for money (VfM) analysis that is considered by the public sector comparator (PSC) offers a mechanism for ex ante evaluation, which intends to provide the business case for PPPs and then enable potential nonfinancial benefits to be considered; however, it was made explicit that there was no mechanism in place to measure whether value and nonfinancial benefits were being attained. This prevailing issue has been repeatedly identified as a failing of PPPs, with an ex post evaluation simply being a review of the final product rather an assessment of the project's holistic performance (EIB 2011a; Haponava and Al-Jibouri 2012). According to the financial advisor (FA-03), the lack of performance measures of nonfinancial benefits in ex ante evaluation adversely impacts critical decision making and hinders the realization of VfM.

At this juncture, attention is drawn to Grimsey and Lewis's (2004, p. 1) definition of VfM, which focuses on "the optimum combination of whole-of-life-cycle costs, risks, completion time and quality in order to meet public requirements;" here emphasis is placed not only on time and quality but ensuring minimal maintenance and sustainability during operations. According to Grimsey and Lewis (2005) and Takim et al. (2009), too much emphasis is placed on the financial benefits that can be acquired from PPP projects; more importance needs to be placed on nonfinancial measures providing social benefits to the community (EIB 2011b).

An effective and efficient PMS can provide a PPP with the drive and direction toward the achievement of its strategic goals and the basis for decision making. Within a PPP, key areas of focus [i.e., critical success factors (CSFs)] are invariably defined and used to identify the needs of the SPVs and stakeholders; KPIs provide the measure of achievement. The interviewees ($n = 23$) stated that KPIs are only specific to the operation phase of PPPs, though it was acknowledged that they should be distributed to other key areas such as initiation, design, construction, and maintenance. The KPIs used within the operations process of a PPP were deemed to be static and unable to respond to changing conditions to which the asset was subjected. This point was raised by a senior procurement advisor (PA-01), who suggested that "Operational KPIs may be suitable for the period when the construction is completed but might not be appropriate for the next 20 years. Mechanism is needed for adjusting some of them over time change, but limited work has been done."

Within the State of Western Australia, a significant number of PPP projects that have been constructed are now in operation. The KPIs that had been developed were designed prior to the partnership phase of the PPP and thus the sustainability of such operational KPIs was deemed questionable by some of the interviewees. The interviewees defined the sustainability of KPIs in PPPs by their ability to be relevant and accommodate the changes to the asset over its life. An effective and efficient PM must reflect the context in which it is operating, yet it would appear that this issue has not been adequately considered. In addressing this issue, a procurement advisor (PA-02) suggested that a mechanism is required to constantly refine KPIs as the asset, macroconditions, and technology are subject to changing conditions. In validating this suggestion, a procurement advisor (PA-03) for the state government made the following comment:

> PPPs are quite challenging because of the length of the contract. How do you deal with the factors raised by change of time? Some of the private prisons built in the 1990s have been modified in terms of their capacity, and the government is in quite a different environment from when they were built. So, what is the government evaluating against, the original business case or the actual outcomes? So the implemented KPIs are not always working. A more dynamic and smart concept should be adopted when designing the KPIs or a formal mechanism should be introduced to review the KPIs. However, the government fails to do so.

A number of issues other than the sustainability of the operational KPIs emerged during the interviews with the two procurement advisors. First, limited attention was being given by the public sector in measuring the project's performance during its early stages (e.g., conceptualization, initiation, planning, and procurement). Second, the process of evaluating the asset's contribution to the public (i.e., local communities) had not been considered and most likely would not be because this would require a modification to the contractual conditions that were in place. Finally, the scope of the operational KPIs is limited because they were deemed to be not suitable for the long-term nature of PPPs. In recognizing these limitations, an operations manager (OM-1) suggested that "The KPIs implemented for the operations of PPPs are too narrow and the indicators about the long-term impacts of the procured infrastructure assets on the public (i.e., local communities/regions) are not involved. But they are very important and the government should carefully consider how to design them. This is an issue being overlooked."

The views regarding the PM of PPPs that were derived from the interviews and have been presented previously can be summarized as follows: (1) traditional TCQ is too simple to capture CSFs and uncertainties that exist in PPPs; (2) the financial-based assessment of VfM cannot reflect the potential nonfinancial benefits provided by PPPs; (3) operational KPIs are not applicable for a long-term period; (4) no formal PM mechanism is available for refining the launched KPIs; (5) there are gaps in systematically measuring the preliminary outputs of PPP projects; and (6) the social impacts of the assets are largely ignored.

Recommendations for Improving PPP Performance Measurement

The problem identification was a relatively straightforward process and enabled the interviewees to take stock of the current issue surrounding PM. After this step, interviewees were asked to propose ways to improve PM within PPPs. While acknowledging PM was imperative and that there was a need for change, interviewees were pessimistic that such an initiative would be implemented. Inertia of this nature appeared to stem from political unwillingness, structural rigidity hampered by contractual conditions, and the absence of technological innovation. While there was pessimism about the change process happening in the near future, interviewees expressed their desire for a PM to be launched that considered changes in the state's economic environment as a result of the falling price of iron ore and oil and a reduction in the goods and services tax (GST) contribution from the federal government. A rapid fall in revenue to the state's budget has resulted in a reduction of infrastructure spending. Thus, PPPs have now become a valuable proposition for new infrastructure investment. With this in mind, a public client (PC-03) suggested "now it's possibly the right time to address performance measurement in PPPs so we can look at future proofing our assets using tools such as Building Information Modeling (BIM)."

Process-Based Performance Measurement

Many of the interviews ($n = 17$) suggested that the PM adopted for PPPs should be robust and take a project lifecycle perspective so as to accommodate uncertainties and complexities (e.g., those relating to documentation, financing, taxation, and technical details) that so often materialize from the initiation and planning and procurement phases of a project. Contrastingly, however, the director of the public authority (PC-01) and a leading financial advisor for PPPs (FA-01) suggested that a lifecycle approach for PM was too cumbersome to implement due to the complexity associated with the stakeholder network and a project's longevity. Despite these difficulties, several innovative ideas to overcome such hurdles were promulgated. For example, a procurement advisor (PA-01) suggested that a process-based evaluation would be a promising way to address a lifecycle perspective for PM. A process approach is akin to the use of stage gates and concentrates on evaluating the deliverable (i.e., tangible and intangible outputs) of each project phase using a series of performance measures. This approach was also reiterated by an architect (A/DM-02) who stated that a "PPP should be evaluated against the development process of the project rather than the finally-procured asset" and a senior legal advisor (LA-02) who stated "A performance evaluation systematically conducted to measure the deliverables of each project phase by using relevant phase-based performance measures will be a feasible approach to replace 'traditional' ex post evaluation in PPPs."

Interviewees who advocated a lifecycle PM indicated that a realistic VfM assessment was required to underpin this approach through the inclusion of tangible and intangible measures; for example, a senior financial advisor (FA-03) made the following comment: "A lifecycle performance measurement must be accompanied with a real lifecycle VfM assessment; otherwise, it will fail in meeting your expectation. The government always stated the tool they used to determine VfM is 'lifecycle'; but this is not true, because that method, such as the PSC, is only financially based or an assessment for project lifecycle cost. VfM must be strategically addressed throughout the project lifecycle and so its evaluation should include the qualitatively and quantitatively objective performances of the assets (e.g., broader community outcomes). All of these cannot be reflected by the project's proposed cost benefits."

It may be necessary to place a strategic emphasis on the creation and assessment of VfM with its evaluation requiring the determination of quantitative and qualitative outputs. Thus, a consideration of the contribution of a PPP to a local community will be required, for example, in the case of a school its ability to enhance educational quality, and for a hospital to improve patient satisfaction.

Table 3. Summary of the Main Findings Derived from the Interviews

Shortcomings of existing PPP performance evaluation	Recommendations for improvements
TCQ is unable to capture CSFs and uncertainties of PPPs	Stakeholder-oriented performance measures
Cost-based VfM assessment is not able to reflect potential nonfinancial benefits of PPPs	Real lifecycle VfM assessment covering both qualitative and quantitative issues
Operational KPIs are not sustainable for long-term contractual period of PPPs	Design of a review mechanism for operational KPIs in PPPs
No PM mechanism is provided for systematically measuring the deliverables of the inception stages of PPPs	Promoting process-based lifecycle performance measurement to replace traditional ex post evaluation
Social impacts of the facilities are largely ignored	Process-based performance measurement with an emphasis on assessing product outcomes

Stakeholder-Oriented Performance Measures

A lifecycle- or process-based PM approach needs to reflect the deliverables that are produced from each phase of a project (LA-02). With this in mind, what kind of performance measures will be involved in a lifecycle PM? A defining feature of a PPP is its stakeholder network. Therefore, many of the interviewees ($n = 19$) indicated that a stakeholder orientation was an appropriate strategy for designing performance measures. Such measures not only examine the stakeholder satisfaction but also their expectations. The public, which are customarily end users, form a critical component of the stakeholder network and thus performance measures must be married to their needs. In recognizing this need, a design manager (A/DM-01) made the following comment: "Stakeholder issues, particularly end users of the assets, should be added to the performance measurement of the operation of a PPP, especially that of hospitals and stadiums; however, this is relevant to not only end-users' satisfaction but also their willingness to use the public assets for a long period."

In addition to the public's needs, a contract's advisor also reinforced the requirements to ensure employees are satisfied during the operation of a facility, particularly the impact that changing technology and functional use can have on morale and productivity. In the case of a hospital, the contract advisor (CA-01) provided the following example: "To measure the holistic performance of a PPP, such as a hospital, the measurement approach must be against the current functionality as well as the maintenance and the delivery of future changes, such as changes in technologies and functional use. In fact, they are very important for the government as the asset will be handed back after the concession period ... we also have to be concerned with not only patients' satisfaction, but also professional employees' performances and satisfaction such as doctors, nurses, midwives and even porters because all of them can determine the service quality of the hospital."

Implicitly in this case is the need for future proofing an asset, and again it is highlighted with emphasis being placed on adaptability and flexibility to change. The lack of a formal mechanism to ensure the future proofing of an asset was also identified by a number of interviewees ($n = 12$).

Difficulties in Implementing a Lifecycle PM

The introduction of new PMS will be an arduous task for organizations and their PPP projects. Such difficulties must be identified prior to the PMS's implementation; if not, the probability of failure will be high (Neely et al. 2005). It was widely acknowledged among interviewees ($n = 20$) that this was a problematic issue, but it was suggested that access to data and the subsequent analysis of KPIs would determine the effectiveness of a new PMS. Obtaining the necessary data was identified as posing the main hurdle, though it was suggested that if building information modeling (BIM) was used in conjunction with construction-operations building information exchange (COBie), the ability to implement an effective PMS would be significantly improved. According to Love et al. (2015), a PMS juxtaposed with BIM can enable assets to be future proofed because it provides key decision makers with the ability to make informed decisions across a project's lifecycle.

Apart from the issues pertaining to obtaining and managing data, a public sector director (PC-01) and a procurement advisor (PA-03) suggested that the abatement regime was also a problematic issue. The abatement regime of a PPP is a mechanism implemented to provide a financial incentive for the service provider (i.e., the private entity participating in the asset's operation). It is directly linked to the payment to the private sector and can be used to monitor whether the organization responsible for providing the public service can meet the specified requirements. According to PC-01 and PA-03, a wider abatement regime, which is able to cover tangible and intangible issues rather than the output quality and quantity of the PPP operations, should be designed with the lifecycle PM. They also proffered that such a new abatement regime must be a balanced mechanism without substantially increasing the lifecycle cost of the project; otherwise, the potential profitability will be reduced.

Proposed Lifecycle Performance Management Framework

The findings derived from the interviews are summarized in Table 3. According to these, it has emerged that a lifecycle PMF that accommodates a VfM assessment, and tangible and nontangible outputs that incorporate a stakeholder orientation, is favored (Fig. 2). It is envisaged that the proposed PMF can address the shortfalls that currently exist with measuring the performance of PPPs, with specific emphasis being placed on the deliverables required at each phase of a project. In addition, the PMF contains instruments to enable stakeholder orientation to be implemented through the inclusion of measures that focus on satisfaction and expectation (i.e., innovation, asset sustainability, and impacts on the public)

The framework can marry with the inherent complexities of PPP stakeholder networks by incorporating a variety of key stakeholders such as public client, creditor, shareholder, concessionaire, subcontractors, end users, and professional staff who are associated with the service provision. Essentially, the usefulness and applicability of the stakeholder-oriented PMF has been widely acknowledged through methods such as the performance prism and the balanced scorecard (Neely et al. 2001, 2002; Liu et al. 2015d).

The proposed lifecycle PMF is grounded in practice and provides a mechanism to dynamically review the operational KPIs as well as the balanced abatement regime. Such innovative mechanisms provide assistance in (1) ameliorating the ability of the operational KPIs to accommodate the changing business environment within which the asset is being utilized, (2) encouraging private entities to adopt a lifecycle PM approach, and (3) ensuring the

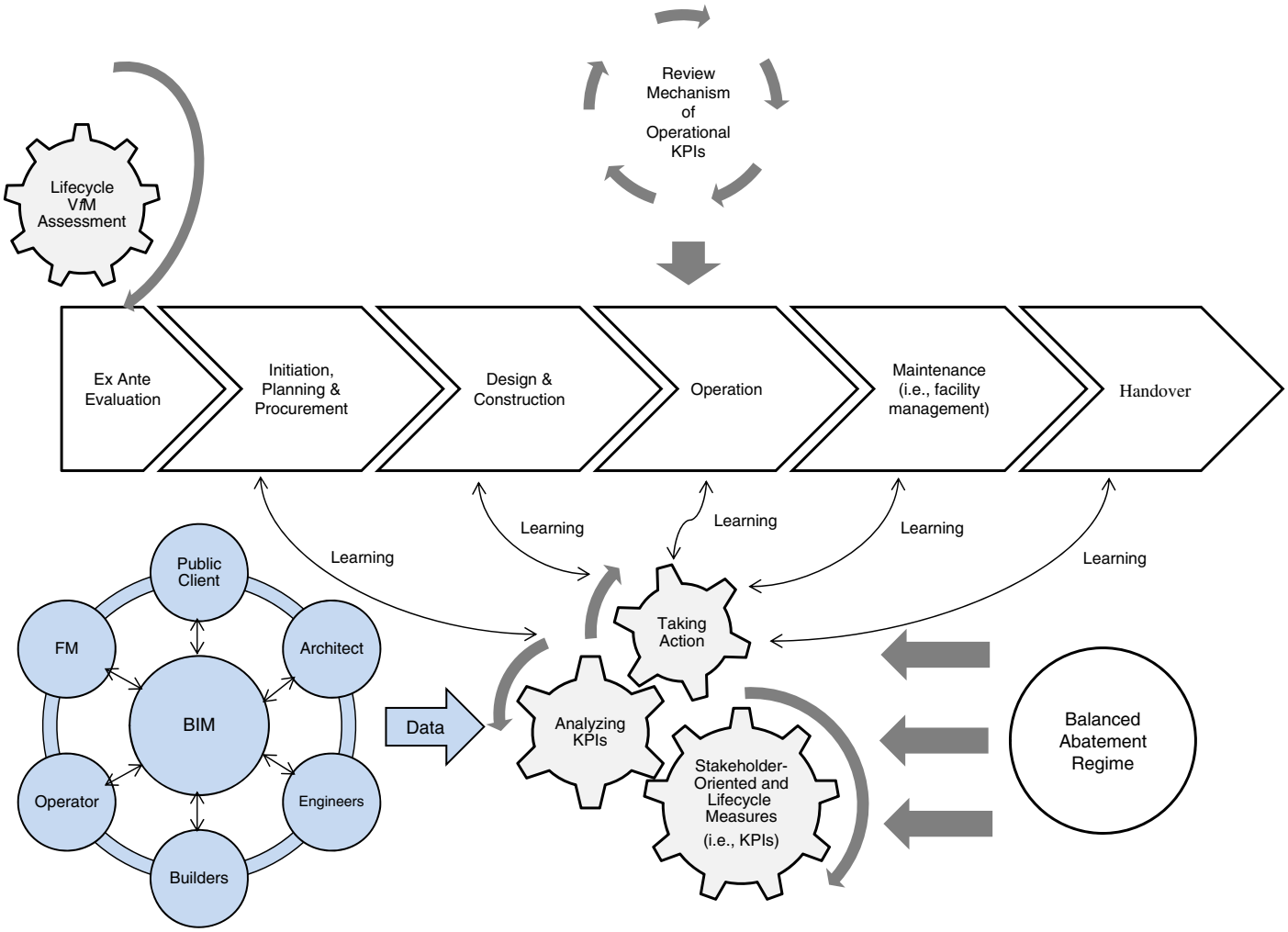

Fig. 2. Lifecycle- and process-based PMF of social infrastructure PPPs

involved private sector partners adequately attend to predetermined requirements without substantially increasing a project's lifecycle cost and reducing the profitability. A central tenet of the lifecycle PMF is the enabling role of BIM; it not only provides digital representation of the physical and functional characteristics of an asset, but also provides key decision makers with the ability to make informed decisions across a project's lifecycle. When aligned with a series of core indicators that are used for PM, it is suggested that BIM can act as a catalyst for future proofing PPPs and enable the successful management of an asset throughout its lifecycle. A detailed review of the enabling role that BIM can play in enacting PM in PPPs can be found in Love et al. (2015).

Conclusion

PPPs are a popular strategy for procuring public assets. They provide relevant public services when many governments have been and are being subjected to constrained budgets and there is still a need for infrastructure development. While there have been ubiquitous studies examining all facets of PPPs over the last two decades, there has been limited emphasis placed on their performance measurement. With this in mind, this paper aims to contribute to the PPP body of knowledge by empirically interpreting the current state of performance measurement of PPPs and identifying a new direction for its improvement. Consequently, an interpretivist approach was conducted that relied on interviews with 25 stakeholders with extensive experience with delivering social PPPs.

The research identified that the performance evaluations of PPPs during the design and construction phases remained reliant on the iron triangle of TCQ, though an array of qualitative and quantitative KPIs are widely applied and used for the projects' operations. There was widespread consensus among the interviewees that the conventional TCQ approach was simplistic and thus did not accommodate the complexity and uncertainty that surrounded PPPs. In addition, it was revealed that there is no commonly agreed on mechanism to capture all critical deliverables to measure if key stakeholders' expectations and satisfaction were to be met.

Emerging from the findings was the proposal of a lifecycle PMF that strategically places emphasis on the creation of VfM, which focuses on financial and nonfinancial costs and benefits. This PMF also integrates with the phase-based and stakeholder-oriented measures and therefore it can enable the public and private sector organizations that embark on a PPP to essentially oversee all critical tangible and intangible deliverables and improve the project's performance, which cascade down from initiation to maintenance. Further, the potential difficulties of implementing the lifecycle PM in PPPs were also identified, including data efficiency and rational incentive mechanism. Therefore, the enabling and improvement

mechanisms of BIM and balanced abatement regime were identified to ensure the effectiveness of a lifecycle PMF for PPPs.

As a consequence of the findings, a lifecycle PMF was empirically developed for PPPs. This PMF constitutes a real lifecycle VfM assessment, stakeholder-oriented performance measures, and a systematic review mechanism of operational KPIs, all of which are supported by the BIM and a balanced abatement regime. Accordingly, the proposed PMF is considered to be an effective and efficient PM approach because it will overcome the problems associated with an incomprehensive evaluation in PPPs. Future research is required to validate the proposed framework and therefore two detailed case studies and a questionnaire survey are presently being conducted. Case studies relying on semistructured interviews and review of documentary sources will be used to examine the feasibility and practicability of the developed model, while confirmatory factor analysis (CFA) is going to be applied to analyze the survey results and quantitatively confirm the main components of the model.

Acknowledgments

The authors would like to thank those participants who participated in this research. The authors would also like to acknowledge the financial support provided by the Australian Research Council (LP120100347).

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