Comparative performance of PPPs and traditional procurement projects in Indonesia

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Abstract

Purpose – The purpose of this paper is to investigate the outcomes of Indonesian power projects as representative projects of Asian emerging economies that were procured via public-private partnerships (PPPs) and traditional public sector procurement. Power generation infrastructure delivery in emerging economies frequently seeks private participation via PPPs as one of the key mechanisms to attract private finance. Undertaking a comparative benchmark study of the outcomes of Indonesian power projects provides an opportunity to explore the historic evidence as to whether PPPs deliver better outcomes than traditional public procurement in emerging economies.

Design/methodology/approach – This paper reports on a study of the performance of 56 Indonesian power projects procured via either PPPs or traditional procurement. First, it focusses on project time and cost outcomes of power plant facility during construction and commissioning and then extends this comparison to consider the operating availability of power plants during their first two years of operation.

Findings – The results indicate that PPP projects had superior time and operating availability to those procured traditionally whereas no significant differences were identified in the cost performance between PPPs and traditionally procured projects. These findings highlight the importance of adopting policies that are supported by broader sources of international financiers and high quality power plant developers.

Research limitations/implications – The quality performance analyses of projects (based on equivalent available factor indices) were limited to the power plants in the Java-Bali region where the majority of projects are large scale power plants.

Practical implications – This study provides an empirical basis for governments of emerging economies to select the most beneficial procurement strategy for power plant projects. It highlights the importance of selecting experienced providers and to adopt policies that attract high quality international project financiers and power plant developers. This includes the need to ensure the commercial viability of projects and to seriously consider the use of cleaner power technologies.

Originality/value – This study is the first to compare the outcomes of power projects in Asian emerging economies delivered via PPPs against those delivered by traditional public procurement that includes consideration of the quality of the delivered product.

Keywords Asian emerging economies, Comparative performance, Power plant projects, Procurement strategies

Paper type Research paper

1. Introduction

Power generation infrastructure delivery in emerging economies frequently seeks private participation via public-private partnerships (PPPs) as one of the key mechanisms to attract private finance and, thus, overcome financing gaps in government budgets (2009; Eberhard and Gratwick, 2011). The Asian Development Bank projected that coal will continue to have a large share of the energy mix in the Asian and Pacific regions. The consumption of coal is projected to increase by 81 per cent between 2010 and 2035 (Asian Development Bank, 2013) and this concerns many commercial finance institutions who seek policies that drive

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reductions in carbon emissions (Williams, 2013). Conditions imposed as a part of international financing structures have led to increased support for power projects that utilise renewable technologies. These international project finance policies may have different impacts depending on how the power stations are procured. It is, therefore, important to compare outcomes of power projects in Asian emerging economies via PPPs vs those delivered by traditional public procurement.

This study investigates power projects in Indonesia as representative projects of Asian emerging economies. The Indonesian power project situation is insightful as since 2000 the government has procured numerous new facilities via both PPPs and traditional public delivery. Undertaking a comparative benchmark study of the outcomes of Indonesian power projects provides an opportunity to explore the historic evidence as to whether PPPs deliver better outcomes than traditional public procurement in emerging economies. Such a comparative analysis offers the potential to greatly benefit decision makers as they consider appropriate delivery strategies for future power projects, either procured using PPPs or a traditional public procurement method.

This benchmarking study considered time, cost, and quality performance. For project time and cost performance, the period of investigation was from when private contractual commitments were made until the actual completion of construction and commissioning. Project cost performance was measured based on public sector budgets and costs for the different procurement strategies. The cost comparison took no account of the financial return to the private sector. For example, the risk allocation within a lump sum traditional Engineering, Procurement and Construction (EPC) contract may insulate the public sector from financial consequences of construction cost overruns. Should a contractor experience construction internal cost overruns these would not influence the outcome of the cost performance analysis based on the signed contracts. The study includes comparison of power plant availability during the first two years of operation and this outcome is used as an indicative measure of project quality performance. Availability of adequate power supplies is paramount to sustain the rapid economic growth in emerging economies where electricity demand is high.

The paper is structured such that it outlines the context of infrastructure delivery in emerging economies and considers previous international benchmarking studies of the performance between PPPs and traditional power projects. It then goes on to outline the research method adopted for comparing the performance of power projects in Indonesia and presents the results of a comparative analysis of power plants procured via either PPPs or traditional procurement. The paper then discusses the findings and draws a number of conclusions and their relevant policy implications.

1.1 Power plant development programme in Indonesia

Indonesia adopts a single buyer electricity market where it allows for the government to invite private sector participation in generating electricity as independent power producers (IPPs). It does this as a mechanism to: seeking external finance, internationalise practices and choice of technology, and seek to develop a deeper internal market for project financing. A power purchase agreement (PPA) governs the contractual relationships between the public and private sector in IPPs that typically assigns the private party to finance, design, construct, and operate a power plant facility in return for performance-based payments from the public sector party over a long-term concession period. This PPA structure is consistent with the general principles of PPPs. Accordingly, IPPs in a single buyer market models have been classified as PPP power generation projects (Conrad *et al.*, 2008).

Indonesia is in the process of planning and delivering new electrical generation projects totalling some US$97 billion from 2015 to 2024 where private power generation will constitute more than 60 per cent of the investment (Perusahaan Listrik Negara, 2014).

The remaining percentage of the investment will be procured through traditionally procured public procurement where the government uses combined public finance and bilateral loan facilities to finance construction and commissioning of power plant facilities. The delivery of power plant projects is dominated by the use of PPPs and traditional public procurement like the EPC contracts and thus the question is frequently raised as to which procurement approach delivers the greatest value.

International project investors from the developed economies have participated in Indonesian PPP power projects since the late 1990s (Wells and Ahmad, 2007). Interestingly, project developers and financiers from regional economies, especially China and India have increased their participation in offshore infrastructure projects while many other international infrastructure investors have concentrated on their own domestic markets (Hazard *et al.*, 2009; Inderst and Stewart, 2014; McDonald *et al.*, 2009). The changing landscape of financial markets warrants closer investigation to evaluate the availability of sponsors and finance for power projects and the consequence of these changes on delivery and operational performance.

1.2 International benchmarking studies on project procurement

Whilst there is a significant body of knowledge of PPP transactions for the provision of power infrastructure in emerging economies (Chan *et al.*, 2010; Gratwick and Eberhard, 2008; Woodhouse, 2006), this literature fails to take into account whether PPPs provide better outcomes than the alternative traditional public procurement for infrastructure projects in emerging economies. Frequently, it is simply assumed that PPPs are appropriate because the financing mechanism within a PPP addresses the immediacy of constrained government budgets. For instance, studies on critical success factors in PPPs have focussed on the commercial transaction but there have only been limited discussions on project performance (even if limited to the construction and operation phase) (Lam *et al.*, 2011; Qiao *et al.*, 2002; Zhang, 2005). These previous studies into PPPs in emerging economies emphasise asset-based solutions rather than service-based outcomes. This is in contrast to countries that have sophisticated PPP experiences like Australia which use output-based specifications that drive the public sector to focus on service delivery (Duffield, 2010; Javed *et al.*, 2013). This difference begs the question whether the benchmarking findings from studies in industrialised countries are applicable for emerging economies, particularly when the access to finance and experienced project developers for a project is also so different.

There have been few studies which compared the performance of PPP and traditional procurement. Raisbeck *et al.* (2010) studied time and cost outcomes from PPPs and traditional public procurement projects in Australia. They found that cost performance in PPPs was better for traditional procurement projects while there was no significant difference of timelines of project completion between the two procurement methods. A benchmarking study in the UK suggested that PPPs had better time and cost performance (MacDonald, 2002). By contrast, Blanc-Brude *et al.* (2006) discovered cost escalation of over 24 per cent in PPPs when they studied 227 road projects in Europe. Table I summarises the key findings of these previous benchmark studies. It is evident that these benchmarking studies of performance between PPPs and traditional projects focussed mainly on *ex ante* project operation stage and included consideration of social, transport, water, and IT projects. The number of sample of projects in these previous studies varied from 1 to 227 projects.

Whilst the benchmarking study of Raisbeck *et al.* (2010) may be the most comprehensive benchmarking study to date, the data were based on an aggregate sample of projects across various sectors. This approach has been questioned by Cheung and Chan (2011) who argue that project complexity varies between sectors like water, transport, and power and that these need to be separately considered. Although whole-of-life consideration between construction and operation becomes an important feature to attain value for money in PPPs

(Grimsey and Lewis, 2005), few studies have considered project operating performance. Bougrain (2012) investigated energy saving in a PPP building project in France during its first four years of operation but the study did not compare the cost saving outcomes against traditional procurement.

It is concluded that the rapid economic development in Asia necessitates a significant injection of finance to keep pace with the expanding provision of economic infrastructure including power plants. Some funds are available via governmental budgets yet finance is still sought from international and domestic project finance markets and one attractive mechanism is to source finance via a PPP. Because of the unique nature of projects in emerging economies, testing of the value gained from alternate procurement strategies such as PPPs and traditional public procurement is required. Further, benchmarking project performance between PPPs and traditional public procurement should be comprehensive, be sector-specific and incorporate the performance of projects both *ex ante* and *ex post* operation if the most appropriate procurement strategy is to be selected.

2. Methods

The proposed approach is to undertake a detailed comparison of the development, delivery, and operation of power projects in Indonesia against the performance criteria of time, cost, and quality.

2.1 Data sources of Indonesian power projects

The power plant projects used in this study are located on the three economic corridors of development in Indonesia, namely, the Western part of Indonesia, Java and Bali, and the Eastern part of Indonesia. These three economic corridors were defined in the Master Plan for Acceleration and Expansion of Indonesia (Coordinating Ministry of Economic Affairs of Indonesia, 2011). The projects contain project time and cost performance of 56 power projects that have been procured through PPPs and traditional public procurement across all Indonesia, see Tables II and III. The set of 28 PPP project have been matched against 28 comparable traditionally procured projects using the selection criteria detailed below. Detailed metrics on quality were only available for projects procured in Java and thus a subset of Java-Bali region projects was taken from the 56 projects in the sample resulting in 13 PPPs and 12 traditionally procured projects being used for the benchmarking of quality. The Java-Bali region is the most developed region in Indonesia and its electricity supply supports the largest industrial demands in Indonesia. For example, Java-Bali accounted for 75 per cent of the total country electricity sales in 2014 while the rest of the Indonesian archipelago shared the remaining 25 per cent of the total sales (Perusahaan Listrik Negara, 2014). The Java-Bali power projects analysed in this research were located in four provinces, namely: West Java, Central Java, East Java, and Banten.

Study	Sectors	Number of project data	Project measurement metrics	Project study timeframe
MacDonald (2002)	Building and civil engineering sector	50	Time and cost	*Ex ante* commercial operation
Blanc-Brude *et al.* (2006)	Road sector	227	Cost	*Ex ante* commercial operation
Raisbeck *et al.* (2010)	Transport, water, IT, and social infrastructure	54	Time and cost	*Ex ante* commercial operation
Bougrain (2012)	Energy	1	Operation cost efficiency	Commercial operation

Table I. A summary of benchmarking studies of PPPs and traditional procurement

Table II. Project data and performance of Indonesian PPP power projects

No.	Project ID (i)	Location (province)	Fuel type	Total installed capacity (MW)	$P_{\text{PPP}}^{\text{time}}$	$P_{\text{PPP}}^{\text{cost}}$
1.	Project P.1	West Java	GFPP	84	1.00	1.00
2.	Project P.2	West Java	GFPP	50	1.00	1.00
3.	Project P.3	West Java	GTPP	90	0.98	1.00
4.	Project P.4	West Java	GTPP	110	0.99	1.00
5.	Project P.5	West Java	GTPP	63	1.04	1.00
6.	Project P.6	West Java	CFPP	660	1.37	1.00
7.	Project P.7	Central Java	CFPP	1,320	1.03	1.00
8.	Project P.8	Central Java	CFPP	562	1.48	1.00
9.	Project P.9	East Java	CFPP	800	0.98	1.00
10.	Project P.10	East Java	CFPP	1,230	1.31	1.00
11.	Project P.11	North Sumatera	HPP	180	1.08	1.00
12.	Project P.12	South Sumatera	GFPP	150	1.07	1.00
13.	Project P.13	South Sumatera	GFPP	80	1.14	1.00
14.	Project P.14	Riau Islands	CFPP	14	1.58	1.17
15.	Project P.15	Riau	CFPP	12	3.14	1.16
16.	Project P.16	Riau	GFPP	12	3.31	1.16
17.	Project P.17	Lampung	CFPP	13	1.85	1.21
18.	Project P.18	Lampung	CFPP	14	1.24	1.13
19.	Project P.19	East Kalimantan	CFPP	14	2.70	1.08
20.	Project P.20	East Kalimantan	GFPP	82	1.07	1.00
21.	Project P.21	Central Kalimantan	CFPP	12	3.44	1.16
22.	Project P.22	West Kalimantan	GFPP	65	1.66	1.10
23.	Project P.23	West Kalimantan	CFPP	54	2.27	1.22
24.	Project P.24	South Sulawesi	GFPP	60	1.28	1.00
25.	Project P.25	South Sulawesi	GFPP	60	1.18	1.00
26.	Project P.26	South Sulawesi	CFPP	200	1.59	1.11
27.	Project P.27	North Sulawesi	CFPP	110	1.22	1.00
28.	Project P.28	North Sulawesi	GTPP	20	1.01	1.00

Notes: CFPP, coal-fired power plant; GFPP, gas-fired power plant; GTPP, geothermal power plant; HPP, hydro power plant

2.2 Project selection criteria

Careful selection of the project sample set is important to avoid bias in choosing projects that have been known for their successful or underperforming outcomes (Raisbeck *et al.*, 2010). For this study, the selection criteria of the benchmarking study from Raisbeck *et al.* (2010) were adapted to select representative sample projects from the pools of the PPP and traditional power projects. Specifically, this study focusses on the period between contractual commitment and actual project completion of construction and commissioning in order to measure project time and cost performance.

2.2.1 Criterion 1: power projects completed construction phase since 2000. It is considered sensible to choose projects for both PPP and traditional power projects that have been completed since 2000 when the country's economy had gradually recovered from the financial crisis that occurred in 1997.

2.2.2 Criterion 2: projects that are in operation. This study only considers power plant projects that involved major construction and are currently operational and providing electric supplies. The project data were gathered on Indonesian projects for the period between 2000 and 2014. During this period the PPP projects adopted a variety of technologies while the traditional project delivery involved the so called "the first 10,000 power development program" which focussed on the development of coal-fired power plants. In the traditional projects studied, the Indonesian Government raised a large proportion of finance from China in return for adopting coal-fired power products and services. All these projects utilised a conventional subcritical coal-fired technology.

Table III. Project data and performance of Indonesian traditional power projects

No.	Project ID (i)	Location (Province)	Fuel type	Total installed capacity (MW)	P^{time}_{Trad}	P^{cost}_{Trad}
1.	Project T.1	West Java	CFPP	625	1.54	1.00
2.	Project T.2	Banten	CFPP	600	1.09	1.00
3.	Project T.3	Banten	CFPP	945	1.60	1.00
4.	Project T.4	West Java	CFPP	990	1.50	1.06
5.	Project T.5	West Java	CFPP	1,050	2.14	1.00
6.	Project T.6	Central Java	CFPP	630	1.79	1.06
7.	Project T.7	Central Java	CFPP	660	1.87	1.00
8.	Project T.8	East Java	CFPP	630	2.15	1.00
9.	Project T.9	East Java	CFPP	660	1.75	1.09
10.	Project T.10	East Java	CFPP	700	2.12	1.02
11.	Project T.11	Aceh	CFPP	220	1.46	1.00
12.	Project T.12	North Sumatera	CFPP	440	2.18	1.00
13.	Project T.13	West Sumatera	CFPP	224	1.75	1.00
14.	Project T.14	Riau	CFPP	200	1.18	1.00
15.	Project T.15	Bangka Belitung	CFPP	60	2.06	1.00
16.	Project T.16	Bangka Belitung	CFPP	33	2.31	1.00
17.	Project T.17	Lampung	CFPP	220	2.21	1.00
18.	Project T.18	West Kalimantan	CFPP	100	1.56	1.00
19.	Project T.19	West Kalimantan	CFPP	55	1.30	1.00
20.	Project T.20	East Kalimantan	CFPP	220	1.34	1.00
21.	Project T.21	Central Kalimantan	CFPP	120	1.31	1.00
22.	Project T.22	South Kalimantan	CFPP	130	2.00	1.18
23.	Project T.23	South Sulawesi	CFPP	100	1.94	1.18
24.	Project T.24	South Sulawesi	CFPP	50	2.38	1.14
25.	Project T.25	Gorontalo	CFPP	55	2.89	1.00
26.	Project T.26	Nusa Tenggara Barat	CFPP	50	1.71	1.42
27.	Project T.27	Maluku	CFPP	30	1.67	1.00
28.	Project T.28	Ende	CFPP	14	2.53	1.37

2.2.3 Criterion 3: project capital size is larger than US$20 million. Projects were gathered from the project pools with minimum size of capital expenditure equal to US$20 million.

2.2.4 Criterion 4: similar number of PPP projects to traditional projects in each pool. In total, 28 PPP projects were available for evaluation and these projects were matched with a sample of 28 traditional projects that have a similar level of complexity and scale.

2.2.5 Criterion 5: projects of similar technical complexity. This study classifies the level of project complexities based on the power generation technologies and power capacity sizes. Technical complexity refers to the use of modern power stations that incorporate mechanisms to achieve maximum energy to fuel ratios. It focusses on thermal-based power plants with minimum power capacity of 12 MW. Project size is classified into four categories: small size (less than 50 MW); medium (between 50 and 500 MW); and large (above 500 MW).

Permission was granted by the Ministry of Energy and Mineral Resources of Indonesia to summarise project information regarding Indonesian power development projects consisting of PPPs and traditional procurement projects. Public information was available regarding project timing and commercial documents were reviewed to glean unitised data for project development costs and construction cost overruns. These commercial documents included PPAs of PPPs and construction contracts for traditional projects. Specific identifiers have been removed from the projects for confidentiality reasons. Clearance was also obtained from the Java-Bali Dispatch Centre to collect and review information regarding quality performance analysis of power plants.

2.3 Project efficiency measures: project outcome metrics

The relative performance of PPPs and traditional procurement were measured against three key project performance measures of time, cost, and quality. The detailed performance metrics are discussed as follows.

2.3.1 Project time performance. Project time performance was measured using two critical project milestones, construction and commissioning dates as benchmarks. Construction time performance was evaluated based on the period between the date the contract was approved and the completion of the project. For traditional procurement contract approval this was interpreted as the time the contract was signed between the Indonesian Government and the main contractor of the EPC contract. For PPPs approval time was when the public and private parties signed off the PPA.

The metric for measuring project time performance in PPPs and traditional power projects is expressed in the following equation:

$$P^{\text{time}}_{\text{proc},i} = \frac{T_{\text{AC(proc},i)} - T_{\text{CS(proc},i)}}{T_{\text{CC(proc},i)} - T_{\text{CS(proc},i)}} \qquad (1)$$

where $P^{\text{time}}_{\text{proc},i}$ is the project time performance on power plant (i) and procurement method (proc), $T_{\text{AC(proc},\,i)}$ the actual finish date of construction and commissioning of project (i) and procurement method (proc), $T_{\text{CC(proc},i)}$ the contractual finish date of construction and commissioning of project (i) and procurement method (proc), $T_{\text{CS(proc},i)}$ the contractual start date of project construction of project (i) and procurement method (proc), proc: {PPP, traditional}, i the power plant identification number (ID).

2.3.2 Project cost performance. The benchmarking of cost performance was calculated based on the impact of changes in the cost base from the estimates developed by the public sector. It includes financial impacts on the public sector budget attributed to debt finance and construction activities. Although a typical PPP contract assigns project finance and facility development to the private sector, there is a possibility that the private sector may request contract renegotiations when the actual project development costs exceed their estimated budget. This may introduce a risk of budget uncertainty to the public sector party in a PPP project.

In traditional public procurement, the public sector may agree on cost variations that are submitted by the EPC contractor. Although the Indonesian Government often adopts a fixed price lump sum contract for EPC contracts, there are situations where the contractor is entitled to claim a variation for cost escalation. The cost performance for traditional procurement projects was measured between the initial contract price agreed in the EPC contracts (C^1_{trad}) and the final actual cost of the completion of project construction (C^2_{trad}). Project cost escalations in PPPs were measured between the original tariff agreed on the PPA (C^1_{PPP}) and the amendment tariff of the PPA post the completion of project construction phase because of the project cost escalations (C^2_{PPP}). The metric for measuring project cost performance in PPPs and traditional power projects are expressed in the following equation:

$$P^{\text{cost}}_{\text{proc},i} = \frac{C^2_{(\text{proc},i)}}{C^1_{(\text{proc},i)}} \qquad (2)$$

where $P^{\text{cost}}_{\text{proc},i}$ is the project cost performance on power plant (i) and procurement method (proc), $C^2_{(\text{proc},i)}$ the final cost of project construction and commissioning works on power plant (i) and procurement method (proc), $C^1_{(\text{proc},i)}$ the contractual cost of project construction and commissioning works on power plant (i) and procurement method (proc), proc: {PPP, traditional}, i the power plant ID.

The results of project time and cost performance for PPPs and traditional procurement are presented in Tables II and III, respectively. It is worth noting that if the project cost performance, refer Equation (2), results in a ratio of one this can be interpreted as the actual project cost to government equals the planned cost. This does not mean the private sector met their budget. It simply means the Indonesian Government has not had to vary its original deal because the costing risk was transferred to the private sector.

2.3.3 Project quality performance. The time series data of the power plant operation performance were used to measure the quality performance between PPP and traditional power projects. Project quality performance uses the power plant operating availability performance that is measured in the equivalent availability factor (EAF) for each power plant unit. Each power plant can contain more than one unit of operation and they are treated as an independent EAF measurement. Accordingly, one power plant project may have more than one EAF measurement if the project contains more than one power plant unit. The EAF index is derived from the international standard of IEEE 762-2006 which measures the percentage of maximum electric generation available over a period of time (IEEE-SA Standards Board, 2007). The EAF index is considered to be one of the most important performance indices of the IEEE standard number 762 (Carazas and de Souza, 2012). This measurement method has been recognised internationally and used by many international power utilities companies and organisations like the North American Electric Reliability Council (NERC) (North American Electric Reliability Corporation, 2012). The following equations express the quality performance measure that is based on the EAF index:

$$P^{\text{quality}}_{\text{proc},i,m} : \text{EAF}_{(\text{proc},i,m)} \tag{3}$$

$$\text{EAF} : \frac{\text{AG}}{\text{MG}} \times 100 \tag{4}$$

where $\text{P}^{\text{quality}}_{\text{proc},i,m}$ is the project quality performance on power plant (i) and unit number (m) that has been procured using procurement method (proc), $\text{EAF}_{(\text{proc},i,m)}$ the EAF on power plant (i) and unit number (m) that has been procured using procurement method (proc), AG the available electricity generation from a power plant unit, MG the maximum electricity generation from a power plant unit.

The power plant EAF index for the first two years of operation was selected to measure power plant operating performance. Early years of operational life of a power plant are essential to measure power plant performance which is influenced by commissioning process, potential random failure, and operating procedure (de Souza *et al.*, 2012). All of the power projects in the Java-Bali economic region between 2000 and 2014 were selected for this study.

The Java-Bali region is connected in a single electric transmission grid that is remotely managed by the Java-Bali Control Centre (JCC). The JCC governs and automatically records the performance operation of all power plants in the interconnected Java-Bali electric grid, including the EAF index for all units of power plants. The study data consist of the EAF indices of a total 16 power projects and contain 25 units of power plants (detailed information on project quality performance for PPPs and traditional procurement are given in Tables II and III). While the sources of data for time and cost outcomes were aggregated for each power project, the EAF data were available for each unit of power plant. If a power project has more than one power plant unit, a specific project ID was assigned. For example, Project T.2 in the EAF data in Table II has two units of power plants. Accordingly, an EAF value for each unit was assigned to the project ID of Project T.2.1 and Project T.2.2 (see Table IV).

Procurement	Project ID	Equivalent availability factor (%) 1st year	2nd year
PPPs	Project P.1	100.00	98.20
	Project P.2	100.00	98.20
	Project P.3	92.50	99.70
	Project P.4	98.00	97.00
	Project P.5	92.00	98.20
	Project P.6	92.41	86.25
	Project P.7.1	79.67	77.30
	Project P.7.2	75.25	79.70
	Project P.8.1	76.03	62.57
	Project P.8.2	69.85	74.70
	Project P.9	97.12	89.23
	Project P.10.1	94.63	86.33
	Project P.10.2	94.78	93.01
Traditional procurement	Project T.1	39.2	50.76
	Project T.2.1	53.9	87.60
	Project T.2.2	45.5	84.78
	Project T.3.1	48.19	67.35
	Project T.3.2	39.08	38.73
	Project T.3.3	51.52	70.12
	Project T.4.1	62.6	67.83
	Project T.4.2	76.1	58.97
	Project T.4.3	64.36	84.74
	Project T.6.1	74.14	68.49
	Project T.6.2	73.54	58.20
	Project T.9	26.66	60.64

Table IV.
Equivalent availability factor of PPP and traditional Java-Bali projects

2.3.4 Statistical analysis. The groups were compared by a student *t*-test with a significance level of 5 per cent to determine whether there is a significant difference between PPPs and traditional public procurement in terms of time, costs, and performance. The data were confirmed to approximate that of a normal distribution. Analysis of variance (ANOVA) was also conducted to compare time and cost outcomes, respectively, between power projects in the Java-Bali and those outside the region. IBM SPSS Statistics (version 22) was used to perform all statistical analysis (Table V).

3. Results

The results of the comparative performance between PPPs and traditional power projects are presented in Table VI. The time and cost findings are summarised diagrammatically

Outcomes	Performance	Procurement: PPP	Procurement: Traditional	Location: Java-Bali	Location: Outside Java-Bali	Two-way ANOVA: Factor 1: procurement	Two-way ANOVA: Factor 2: location	Two-way ANOVA: Interaction (factor 1 × factor 2)
Time	Average	1.54	1.83	1.44	1.82	$F = 5.42$	$F = 5.81$	$F = 2.73$
	SD	0.74	0.43	0.42	0.67	$p < 0.05$	$p < 0.05$	$p = 0.10$
	Number of observations	28	28	20	36			
Cost	Average	1.053	1.054	1.01	1.08	$F = 0.05$	$F = 6.71$	$F = 0.46$
	SD	0.08	0.11	0.03	0.11	$p = 0.82$	$p < 0.05$	$p = 0.50$
	Number of observations	28	28	20	36			

Table V.
Analysis of variance of time and cost performance

Procurement strategy	Performance benchmarking	Time performance	Cost performance	Quality (EAF) 1st year operation	Quality (EAF) 2nd year operation
Traditional public procurement (trad)	Average	1.83	1.054	54.56	66.51
	SD	0.43	0.11	15.82	14.49
	Number of observations	28	28	12	12
Public-private partnership (PPP)	Average	1.54	1.053	89.40	87.72
	SD	0.74	0.08	10.39	11.43
	Number of observations	28	28	13	13
	Conclusions	$P^{time}_{trad} > P^{time}_{PPP}$ ($p < 0.05$)	No significant cost differences ($p = 0.36$)	$P^{quality}_{trad} < P^{quality}_{PPP}$ ($p < 0.05$)	$P^{quality}_{trad} < P^{quality}_{PPP}$ ($p < 0.05$)

Table VI. Results of the performance benchmarking between PPPs and traditional

in Figure 1 and then the time and cost outcomes are discussed. The quality results are summarised in Figures 2 and 3 and then the findings on quality are discussed.

Figure 1 details the time and cost performance of PPPs and traditional power projects. It appears from these results that projects delivered via a PPP had better time management than traditionally procured projects. There was no apparent difference in cost performance between the two procurement methods. A detailed comparison of project cost, time, and quality are detailed in the following sections.

3.1 Cost performance analysis

The results of the cost performance comparison between PPP and traditional power projects, summarised in Table VI, show no significant difference of project cost performance between PPPs and traditional procurement. The public sector contracting agency assumed on average 5.4 per cent of cost escalations from PPP projects although contractually the private sector were responsible for construction cost overruns. The public sector party in traditional public procurement had assumed on average project construction cost escalations of 5.3 per cent over the original EPC contracts.

Based on the cost overrun ratio, the extent of cost overruns varied between 8 to 22 per cent of original contractual cost in PPP projects. The cost overruns occurred in ten PPP power projects that were located outside the Java-Bali region (Table II). The public

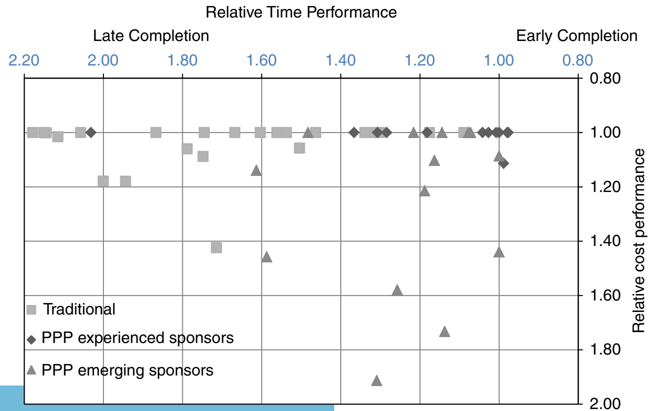

Figure 1. Comparison of project time and cost performance

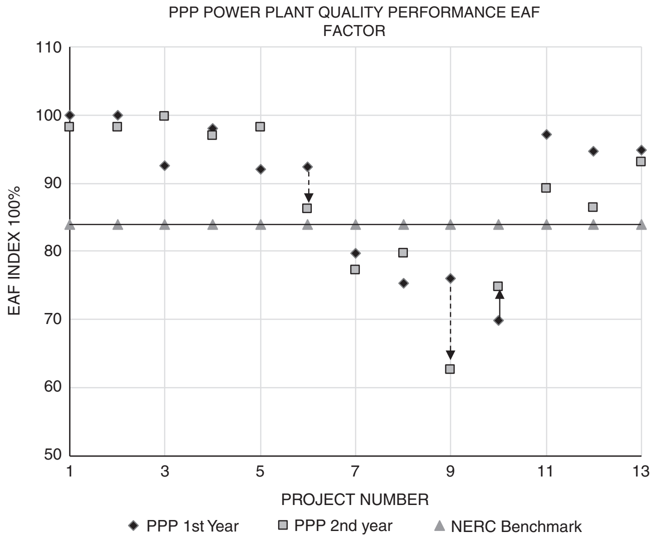

Figure 2.
PPP power plant quality performance measured in the equivalent availability factor

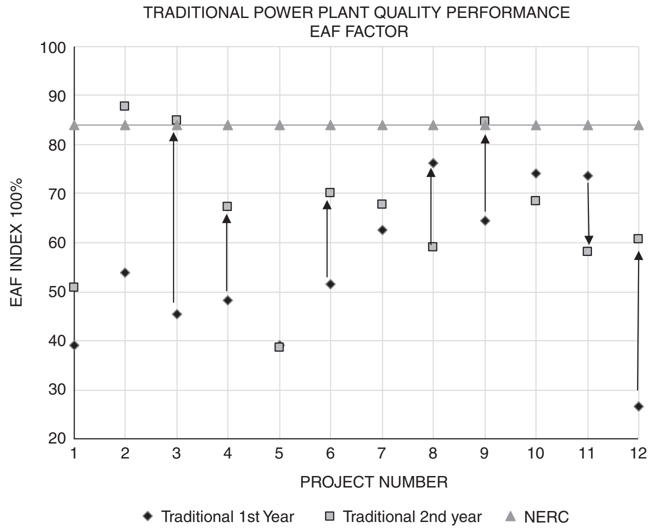

Figure 3.
Traditional power plant quality performance measured in the equivalent availability factor

sector assumed construction cost escalations in nine traditional power projects and the extent of cost overruns varied between 2 to 42 per cent from the original contractual cost. This cost underperformance occurred in traditional procurement projects that were categorised in small, medium, and large capacity sizes.

3.2 Time performance analysis

An investigation of time performance between PPPs and traditional projects has revealed that project time completion delays frequently occur in Indonesian power projects. Time performance results indicate that the average of time delay ratio for PPPs is significantly lower than for traditional power projects, refer Table VI. PPPs completed the construction and commissioning phases on average 54 per cent longer than the original contractual schedule. Traditional projects experienced completion delays of 83 per cent behind the original completion programme and the delays are significantly greater than for PPPs.

Table II shows the ratio of time delays in PPP projects. Time delays occurred in 23 PPP projects and these projects came from various locations, a range of project size/capacity and for projects adopting different types of fuel technologies. These delays varied greatly from 1 to 231 per cent behind the original contractual schedules. The worst performing project on the basis of time was a small size capacity of coal-fired power plant project located in the Central Kalimantan province that is outside the Java-Bali economic region. It can also be identified in Table II that five PPP projects had been completed either on time or ahead the original contractual schedule.

All traditionally procured projects, refer Table III, experienced completion delays and these delays ranged between 9 and 189 per cent longer than the original contractual duration. These delays occurred regardless of a projects location, fuel type, or installed capacity. The worst time performing project was a 55 MW coal-fired power plant project in the Gorontalo province that is outside the Java-Bali economic region. Interestingly, none of the traditional projects were completed either ahead or at the contractual schedules.

3.3 Quality performance analysis

Comparison of project quality performance using the EAF index has revealed that on average PPP projects had statistically outperformed traditional projects by a significant amount over the first two years of a project's operation period. On average, PPPs had EAF indices that were equal to 89.4 and 87.7 per cent of the first and second year of operations. By contrast, traditional power plant units had an average EAF indices of 54.6 and 66.5 per cent, respectively. The average EAF indices in traditional procurement is far below the international benchmarking from the NERC power plants that has average EAF of 84.01 per cent for fossil fuel power plants between 2007 and 2011 (North American Electric Reliability Corporation – Generating Availability Report, 2012). In contrast, the average EAF values on PPP power plants had outperformed the average power plant performance in the NERC region, see Figures 2 and 3.

The analysis of power plant availability performance in Figure 2 shows that PPPs generally had better availability performance than traditionally procured power plants. It can be seen that nine out of 13 units of PPP power plants had EAF indices higher than the international EAF benchmark from NERC in the first and second years of operation. Conversely, all 12 traditionally procured power plant units had availability performance well below the international EAF benchmark from NERC whilst only three power plant units had made improvement of their availability performance above this benchmark in the second year of operation.

The standard Indonesian PPP contract links a major component of the tariff payment to achieving a performance of being available for at least 80 per cent of the time. It appears that the PPP tariff payment has incentivised the majority of PPPs in the interconnected Java-Bali region to meet the required operating performance (measured in EAFs). However, it was noted from Figure 2 that there were four power plant units from two PPPs projects (Projects P.7 and P.8) that had their EAF performance well below 80 per cent during the first two years of operation. The average of the second year EAF indices of Projects P.7 and P.8 were 78.5 and 68.6 per cent, respectively. The contractual structure of Project P.7 is unique in Indonesian standard form of PPA that it assigns operation and maintenance risk to the public sector party. Project sponsors' revenues were based on a finance lease agreement (FLA) that was paid by the Indonesian state electric company on a monthly basis. The FLA scheme provides a mechanism for transfer of technology and management of the power plant operation to the public sector. However, it appears that the benefit of whole-of-life consideration through service integration between infrastructure development and operation and maintenance has not been fully realised in the PPP that was reliant on the FLA. A possible reason for this was that the PPP sponsors only had limited responsibilities to finance, design, and construct the facility while the public sector party assumed long-term responsibilities for operation and maintenance.

Project P.8 was the first large scale Indonesian PPP that was sponsored by a joint venture of a state energy company and domestic project developer post the Asian financial crisis in 1997. The structure of finance for this project was sourced from the project sponsors' equity and credit facilities from one of the export credit agencies in Asia in return for utilisation of power plant equipment and provision of the main EPC contractor from its respective country. Local banks had also participated in the provision loan facilities for the project. The project experienced numerous technical problems during the first years of operation that were reflected in its comparatively a low operating performance.

3.4 Combined cost, time, and quality performance analysis

A footprint area method was adopted to compare performance on the basis of the combined results of cost, time, and operating performance. This method was introduced by Gransberg *et al.* (2013) to compare 18 international transport projects that were based on five performance metrics, namely: technical, time, cost, finance, and context. They compared footprint area of a radar diagram that was constructed based on the five performance measures for each project. This study adapted the footprint area method to compare the performance between PPPs and traditional procurement projects based on the four dimensions, namely: construction cost and timelines, and the annual operating performance over the first two years of operation. The radar diagram of power projects in the Java-Bali region is presented as Figure 4 and details results based on the average project time, cost, and first two years of operating performance in PPPs and traditionally procured

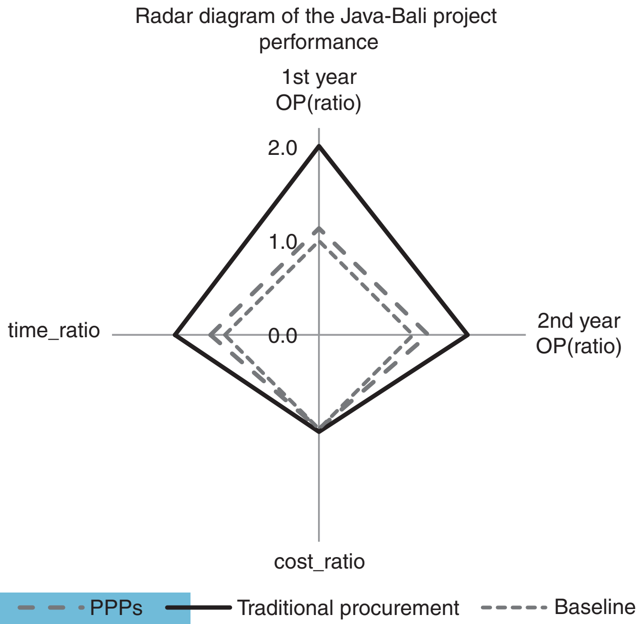

Figure 4.
Radar diagram of project time, cost, and operating performance

projects. The diagram was developed using the first years of operating performance (full data provided in Tables II and III) and their associate time and cost outcomes, refer Tables II and III. The EAF data were normalised to be consistent with the cost and performance measures using Equation (5). In this normalised operating performance ratio, the higher ratio beyond unity indicates negative performance:

$$\mathrm{Op-ratio}_{\mathrm{proc},i,m} = \frac{1}{\mathrm{EAF}_{\mathrm{proc},i,m}} \tag{5}$$

$\mathrm{Op-ratio}_{\mathrm{proc},i,m}$ is the normalised project quality performance on power plant (i) and unit number (m) that was procured through procurement method (proc), $\mathrm{EAF}_{(\mathrm{proc},i,m)}$ the EAF on power plant (i), unit number (m), and that procurement method (proc).

It is evident from Figure 4 that the PPPs projects had superior performance when compared with the traditional projects for the other three measurement factors, namely: the construction timelines, and the first and second years of operating performance. It also appears that traditionally procured projects had experienced some cost overruns although the average was relatively small, approximately 3 per cent over the original budget, this did not occur in PPPs. This indicates that PPPs projects in the Java-Bali region have marginally better financial capabilities and construction management techniques such that they have higher budget flexibilities to manage construction programme. Table VII summarises footprint area for all projects in the Java-Bali which contain a complete set of data of time, cost and operating performance.

The average of footprint area in PPPs is 2.49 and this value is substantially lower than that for traditional procurement (4.78). An independent t-test conducted for footing area data in Table V confirmed that the difference of average footing area between PPPs and

No.	Project ID	Cost_ratio	Time_ratio	Operating performance 1st year	Operating performance 2nd year	Footing area
1.	Project P.1	1.00	1.00	1.00	1.02	2.02
2.	Project P.2	1.00	1.00	1.00	1.02	2.02
3.	Project P.3	1.00	0.98	1.08	1.00	2.06
4.	Project P.4	1.00	0.99	1.02	1.03	2.04
5.	Project P.5	1.00	1.04	1.09	1.02	2.15
6.	Project P.6	1.00	1.37	1.08	1.16	2.63
7.	Project P.7.1	1.00	1.03	1.26	1.29	2.62
8.	Project P.7.2	1.00	1.03	1.33	1.25	2.66
9.	Project P.8.1	1.00	1.48	1.32	1.60	3.57
10.	Project P.8.2	1.00	1.48	1.43	1.34	3.43
11.	Project P.9.1	1.00	0.98	1.03	1.12	2.13
12.	Project P.10.1	1.00	1.31	1.06	1.16	2.54
13.	Project P.10.2	1.00	1.31	1.06	1.08	2.45
14.	Project T.1	1.00	1.54	2.55	1.97	6.23
15.	Project T.2.1	1.00	1.09	1.86	1.14	3.18
16.	Project T.2.2	1.00	1.09	2.20	1.18	3.63
17.	Project T.3.1	1.00	1.60	2.08	1.48	4.75
18.	Project T.3.2	1.00	1.60	2.56	2.58	7.45
19.	Project T.3.3	1.00	1.60	1.94	1.43	4.46
20.	Project T.4.1	1.06	1.50	1.60	1.47	3.95
21.	Project T.4.2	1.06	1.50	1.31	1.70	3.79
22.	Project T.4.3	1.06	1.50	1.55	1.18	3.50
23.	Project T.6.1	1.06	1.79	1.35	1.46	3.91
24.	Project T.6.2	1.06	1.79	1.36	1.72	4.24
25.	Project T.9	1.09	1.75	3.75	1.65	8.22

Table VII. Comparison data for project time, cost, and operating performance traditionally procured projects was statistically significant ($p < 0.05$). These results show that PPPs had an overall time, cost, and operating performance that were substantially better than those in traditional procurement.

3.5 Analysis of the importance of project location to time and cost performance

The benchmarking performance of combined cost, time, and quality of power projects in the Java-Bali economic region raises a consideration whether there was a consistency of performance of power projects between the Java-Bali economic region and those outside the region. A two-way ANOVA was performed to examine the effects of a procurement method and location of a project on project performance, measured in time, and cost outcomes, respectively (Table V). It should be mentioned that project operating performance was not included in this analysis due to the lack of data outside the Java-Bali.

The results of two-way ANOVA on project time and cost outcomes highlight important findings which demonstrate power projects located in the Java-Bali region had on average better cost and time performance than those in the other regions ($p < 0.05$). The two-way ANOVA also confirms that PPPs statistically had better time performance than traditionally procured projects ($p < 0.05$).

4. Discussion

The results of project performance benchmarking are important findings in that they provide empirical evidence on what can be expected from power projects procured using PPPs or traditional public procurement in Asian emerging economies like Indonesia. These are discussed below under the headings of: project cost performance comparison, time performance comparison, and quality performance comparison.

4.1 Project cost and time performance

The project cost comparison of Indonesian power projects shows that there were no statistically significant cost performance differences between PPPs and traditional procurement. This finding differs from previous international benchmarking studies in Australia and the UK which suggested that PPPs had significantly less cost overruns than traditional projects (MacDonald, 2002; Raisbeck *et al.*, 2010). Power projects in the Java-Bali region on average had lower cost overruns than those developed outside this region regardless of the selected procurement strategy to deliver such projects.

This study has revealed important findings that PPPs on average had significantly better time performance than traditional procurement of Indonesian power projects. Based on comparison of the same time period between contractual commitment and actual project completion, it was found that the average delays on Indonesian projects were significantly higher than benchmarking project performance in Australian projects. While project completion in Australia was delayed between 2.3 and 2.5 per cent behind the schedules (Raisbeck *et al.*, 2010), the average delays in Indonesian power projects were 54 per cent for PPPs and 85 per cent for traditional procurement projects. These highlight significant time performance problems because such events occurred in various project sizes and locations. The ANOVA found that project location and procurement method are statistically significant to influence project time performance although a combination between these two factors does not show a statistically significant interaction effect on project time outcomes.

A possible explanation for the extent of project delays relates to the capabilities of project sponsors in PPPs. Investment in PPPs is driven by: the project financial markets appetite for the project, based in part on the size of the capital investment, the selection of the power plant technology and the level of experience of the project developers (Atmo *et al.*, 2015). They found that project sponsors of PPPs in the Java-Bali region had strong financial capabilities and project development expertise to finance construction works and procure proven power plant technology. Conversely, the Electricity Indonesian Society (2010) reported that project sponsors of 17 small and medium PPPs outside the Java-Bali did not have adequate financial capacities to absorb the cost escalation in the construction of power plant facilities, especially when there were significant cost increases in plant materials and equipment.

This research found cost overruns occurred in small and medium coal-fired power projects and all these projects are located outside the Java-Bali region. The medium scale gas-fired power PPP projects in Java-Bali (Table II) are dedicated to meet the electrical demand from an integrated industrial and business complex. The geothermal PPP projects of the Java-Bali receive carbon credit facilities that improve commercial viability of these projects. The international power industry has been supportive of projects that adopt renewable and highly efficient combustion technologies and are therefore less supportive of conventional subcritical coal-fired power plants (Atmo and Duffield, 2014; Atmo *et al.*, 2015). PPPs typically involve high transaction costs that come from tendering, finance arrangements and contract administration (Dudkin and Välilä, 2005). Accordingly, the capital size of PPP projects needs to be sufficient to attract investments from experienced private companies and offset high transaction costs. Linking PPPs to the development of an industrial complex or other source of revenues can also improve commercial viability of medium scale PPP projects.

It appears that experienced power developers are mainly attracted to large scale power projects that are mostly located in the Java-Bali region whilst domestic-led investors seek opportunities in small and medium scale power projects. Selection of fuel type, combustion technology, and project capital size influence the ability of a power project to attract competent project developers.

4.2 Project quality performance comparison

A comparison of project quality performance during the first two years of the operation stage has demonstrated that PPPs delivered significantly better operating performance than for similar traditionally procured projects. This is the period when a power plant starts to generate electricity and hence receive payment from the public sector partner. In other words, payments to the private sector are directly linked to the reliability of operation of the facility and this mechanism appears to contribute to an enhanced operating standard in PPPs. In contrast, it was observed that traditional power projects have a relatively low level of availability during the early years of operating the power station.

It has been revealed that a FLA model of PPP contract does not result in higher operating performance outcomes. It appears that the benefit of whole-of-life consideration through service integration between power plant design, construction, and operation does not maximised in this PPP model. It is acknowledged that it is important to recognise and gain the benefits from the availability of finance and project developers from the regional Asian economies and domestic markets. There appears evidence to suggest that greater control is required in PPPs sponsored by emerging developers if they are to match the operating performance achieved in other PPPs.

5. Conclusions and policy implications

This paper compares the performance between PPPs and traditional procurement methods for Indonesian power projects. It measures the outcomes of a project based on the dimensions of time, cost, and quality performance. Project performance of *ex ante* commercial operation date was used to compare project time and cost performance between PPPs and traditional power projects. These two dimensions of project performance were measured between original contractual commitment and actual completion of project construction and commissioning. The power plant availability performance for the first two years *ex-post* commercial operation date was used to compare project quality performance between these two procurement methods.

Based on investigation of 56 Indonesian power projects, it was found that, on average, there was no significant cost difference between PPPs and traditional procurement projects. It has been demonstrated via ANOVA that power projects in the Java-Bali region have better cost performance than those outside the region regardless of the procurement method adopted.

This study found that Indonesian PPPs had better time performance than traditional power projects. Although this study demonstrated that both PPPs and traditional procurement had experienced project completion delays, traditional projects had suffered from significantly longer delays than PPPs. Project locations that attract experienced project sponsors have significantly enhanced time performance, e.g. the Java-Bali region compared with less attractive locations throughout the archipelago that typically have smaller projects.

The benchmarking performance of operational availability between PPPs and traditional public procurement in Indonesian power projects discovered that the average availability of PPPs was much higher than that of traditional projects. It appears that contractual arrangement linking power plant operating performance and service payments has motivated PPPs to operate at a higher operating standard than traditional projects. On the other hand, the traditionally procured projects had an average operating availability performance that was far below the Indonesian PPPs and an international benchmarking reference for thermal-based power plants.

This study provides an empirical basis for governments of emerging economies to select the most beneficial procurement strategy for power plant projects. It highlights the importance of selecting experienced providers and to adopt policies that attract high quality international project financiers and power plant developers. This includes the need to ensure the commercial viability of projects and to seriously consider the use of cleaner power technologies.

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