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ScienceDirect
International Journal of Project Management 28 (2010) 228–236
International Journal of Project Management
www.elsevier.com/locate/ijproman

Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects

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Received 9 February 2009; received in revised form 10 May 2009; accepted 14 May 2009

Abstract

Performance measurement criteria vary from project to project. Despite much work on the subject, there is no commonly agreed framework of performance measurement on mega projects. To bridge this gap, this research targets to investigate the perception of the key performance indicators (KPIs) in the context of a large construction project in Thailand. The study explores the significance of key performance indicators in perspective of various construction stakeholders (client, consultants, and contractors). Findings indicate that the traditional measures of the iron triangle (on-time, under-budget and according to specifications) are no more applicable to measuring performance on large public sector development projects. Other performance indicators such as safety, efficient use of resources, effectiveness, satisfaction of stakeholders, and reduced conflicts and disputes are increasingly becoming important. This implies that the Thai construction industry is slowly departing from the traditional quantitative performance measurement to a rather mix of both quantitative and qualitative performance measurement on large-scale public sector development projects.

Keywords: Project performance management; Large construction projects; Key performance indicators (KPIs); Thai construction industry

1. Introduction

Project success means different to different stakeholders. A project that may seem successful to the client may be a completely unsuccessful venture for contractors or end users (Toor and Ogunlana, 2008). Invariably, stakeholders have distinct vested interests in a particular project and therefore the perception of success may also vary across various stakeholders (Bryde and Brown, 2005). Particularly, in case of public development projects, where number of stakeholders usually large, it is important to assimilate the viewpoint of all interest groups about the project success. Cox et al. (2003) note that the perception of project success may even vary according to management's perspective. They ascertain that there is a substantial difference between the perception of construction executives and project management about KPIs. It is, therefore, not surprising that different participants think differently while they analyze the performance of a project (Cox et al., 2003).

To clarify some ambiguities related to the scale of project success, Lim and Mohamed (1999) argue that there are two possible viewpoints: macro-level success and micro-level success. The macro viewpoint takes care of the question "does the original concept tick?" Usually the end users and project beneficiaries are the ones looking at project success from the macro viewpoint. The micro viewpoint concerns the construction parties such as consultants and contractors. Furthermore, micro success pertains to traditional triangle of whether the project is on time, within

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doi:10.1016/j.ijproman.2009.05.005

budget, and according to specifications. Briefly, macro success is more concerned about the eventual operation/functions or long-term gains of the project; whereas micro success pertains to profitability or short-term gains.

Cookie-Davies (2002) also offers a distinction between project success – which is measured against the overall objectives of the project – and project management success – which is measured against the widespread and traditional measures of performance against cost, time, and quality. Cookie-Davies (2002) also highlights the difference between the success criteria and success factors. Success factors are those which contribute to achieving success on a project. On the other hand, success criteria are the measures by which the success or failure of a project will be judged. Factors constituting the success criteria are commonly referred to as the key performance indicators or KPIs. Cox et al. (2003) observe that the KPIs are helpful to compare the actual and estimated performance in terms of effectiveness, efficiency and quality of both workmanship and product. In short, success factors are the efforts made – or strategy adopted – to achieve the success on project. Whereas, KPIs are the compilations of data measures (either by quantitative or qualitative data) used to access the performance of the construction operation.

Despite extensive research, there is no general agreement on a set of KPIs for construction projects to-date (Chan et al., 2004). Therefore, there is need for identifying a set of common indicators to be used by construction executive and project managers in measuring construction performance at the project level (Cox et al., 2003). However, it seems difficult as every project has certain unique features and limitations and therefore generalizing the taxonomy of KPIs for all kinds of projects looks fairly impractical. Regardless of these limitations, it is important to comprehend the perception of KPIs on different types of projects carried out in different contexts. Such research endeavors are helpful in sharing the lessons learnt on different projects and to expand the existing taxonomies of KPIs for future projects.

Considering these implications of research on project performance management, the current research attempted to achieve the following objectives:

1. to capture the perception of various stakeholders (client, consultants, contractors) about KPIs on mega construction projects,
2. to investigate if the perception of KPIs differs across:
   a. various construction stakeholders,
   b. firms working independently and in joint ventures, and
   c. various levels of professionals' overall experience and experience as project managers.

2. Literature review

Phua (2004) is of the view that multi-firm project success can be defined and measured, at least at the operational level, as the extent to which projects meet a combination of budget, timetable and technical specifications. Savindo et al. (1992) relate the success of a project to the expectation of its participants which may be owner, planner, engineer, and contractor or operator. According to Munns and Bjeirmi (1996), a project can be considered successful when it is able to achieve some specific objectives; have definite start and end dates; and is completed within a specified time period and according to a set specification. Nguyen et al. (2004) also support the traditional perspective that a construction project is successful when it is completed on time, within budget, in accordance with specifications and to stakeholders' satisfaction.

To explain how project performance is associated with project process, Toor and Ogunlana (2008) present a conceptual model in which they divide project management into process domain and performance domain. Process domain deals with project objectives, devising an adequate project management system, and delivery of product during input, process, and outcome stages, respectively. On the other hand, performance domain focuses on performance goals, establishment of performance enhancement strategy, and performance measurement during input, process and outcome stages, respectively. Toor and Ogunlana (2009) note that performance measurement can be carried out by establishing KPIs which offer objective criteria to measure the success of a project.

Performance measurement in construction project has been dominated by the conventional measures of time, cost, and quality. Atkinson (1999) termed these three measures together as the 'iron triangle'. Despite the simplistic nature of performance measurement through the iron triangle, practice, and research have departed from this approach and new direct and indirect measures are being employed for project performance measurement. For example, Low and Chuan (2006) argue that the measure of project success can no longer be restricted to the traditional indicators which include time, cost, and quality. They advocate the expansion of success measurement towards project management success or product success or both. This differentiation of success criteria is also suggested by various scholars who believe that project success is different from project management success (see: Cookie-Davies, 2002; Shenhar et al., 1997).

Other researchers suggest that in addition to the measures of iron triangle, customer satisfaction (Pinto and Slevin, 1988) and overall satisfaction of stakeholders (Bryde and Brown, 2005) should also be considered in performance evaluation criteria. Some have also given the notion of project team's ability to manage project risks and resolve problems encountered on the project to evaluate the project success (Belout and Gauvreau, 2004). Study of Freeman and Beale (1992) reveals that five most frequently used criteria to measure project success include: technical performance, efficiency of execution, managerial and organizational implications, personal growth and manufacturer's ability and business performance.

In another study of professionals at different managerial levels, Cox et al. (2003) differentiates between quantitative and qualitative measures of success. Their quantitative performance indicators include Unit/MH, $/unit, cost, on time, resource management, quality control, % complete, earned man-hour, lost time accounting, and punch list. Most of these measures also appear in the estimating/costing systems utilized by the majority of construction firms. Qualitative performance indicators of Cox et al. (2003) include safety, turn-over, absenteeism, and motivation. However, Cox et al. (2003) also acknowledge that qualitative indicators are not considered as highly reliable performance and productivity evaluation tools due to their perceived difficulty and/or inability to be measured.

Turner (1993) note the following criteria to measure the success of projects: the facility is produced to specification within budget and on time; the project provides a satisfactory benefit to the owner; the project achieves its stated business purpose; the project meets pre-stated objectives to produce the facility; the project satisfies the needs of project team and supporters; the project satisfies the needs of users; and the project satisfies the needs of stakeholders. In addition to the conventional measures of cost, time, quality, and scope, Westerveld (2003) emphasizes the following KPIs: client's appreciation; project personnel appreciation; users' appreciation; contracting partners' appreciation; and finally stakeholders' appreciation.

In a study of "micro-projects" – projects having a total cost of less than $15,000 – in the developing countries, Sohail and Baldwin (2004) offer 67 performance indicators for monitoring of micro-contracts. These indicators are divided into general indicators (such as 'number of disputes' or 'incidences of delay in the supply of materials, and tools and plant'), time indicators, cost indicators, quality indicators, indicators for inter-organizational co-operation and partnership, and finally, indicators related to socio-economic issues (such as enterprise development, poverty alleviation, and empowerment).

Literature review shows that the performance measurement of construction projects is slowly moving away from the traditional measures (such as cost, time, and quality) towards a rather mix of quantitative and qualitative measures. In the current study, an attempt is made to capture the perception of construction project leaders about a mix of different quantitative and qualitative KPIs for large-scale public sector development projects.

3. Research method

In order to achieve the research objectives stated above, an empirical investigation was carried out on the Second Bangkok International Airport (SBIA) or Suvarnabhumi Airport, a mega construction project in Thai construction industry. Due to its volume, budget, complexity, excessive delays, diversity of stakeholders, involvement of several local and international construction firms, and keen interest of the government due to future business and strategic implications of the project, the SBIA makes a very unique project in Thailand.

Through literature review and preliminary interviews with academic researchers and industry experts, a catalog of 9 KPIs was prepared in form of a questionnaire. This questionnaire was distributed among project managers, deputy project managers, and line managers on the project site of the Suvarnabhumi Airport. The survey was conducted during 2004–2005 while the airport was still in its construction stage. Respondents were asked to rate each KPI based on their professional judgment on a given 5-point Likert-type scale (where 1 = not important at all, 2 = not necessarily important, 3 = important sometimes, 4 = important, and 5 = extremely important). A total of 80 questionnaires were personally delivered to the respondents, together with a covering letter explaining the purpose of the study and assuring them of anonymity. Respondents were also sent an e-mail from the client organization to cooperate with the research team and to respond to the questionnaire. This endorsement of the client resulted in a high response rate and out of total 80 questionnaires, 76 were collected back. This yielded a response rate of 95%.

In addition to the questionnaires, face-to-face interviews were also conducted with 35 respondents of questionnaires who agreed to spare time for interview. The interviewees were mostly project managers (12), deputy project managers (8), and senior line managers (15). It is obvious from their designation that interviewees had extensive experience of project management and the majority of them had previously worked as project manager on construction projects. During the interview, various questions regarding KPIs on large-scale development projects were asked.

4. Background of respondents

Tables 1–5 provide demographic details of the subjects who participated in this study. Most of the respondents (over 75%) were working in joint ventures of project organizations. Few were working in consortiums (12%) and even fewer were working in their parent organizations (11.5%). Almost half of the respondents were project managers, deputy project managers, and construction managers. Others were holding the designation of line managers

Table 1
Respondents' experience in project management.

Experience	In project management	As project manager
<5 years	13	27
6–10 Years	18	21
11–15 Years	13	11
16–20 Years	18	8
21–25 Years	8	7
26–30 Years	4	1
31–35 Years	1	1
36–40 Years	–	–
41–45 Years	1	–

Table 2
Profile of the respondents.

Group	Project manager	Deputy project manager	Project engineer	Line manager	Total responses
CR	1	1	2	3	7
PMC	1	1	–	8	10
CSC	7	7	4	20	36
DC	2	–	–	3	5
CC	3	2	1	10	16
Total	14	11	7	44	76

Note: CR, Client Representative; PMC, Project Management Consultants; CSC, Construction Supervision Consultants; DC, Design Consultants; CC, Construction Contractors.

(quality control manager, contracts manager, design manager, designer coordinator, and site manager etc.). As all the respondents were professionally positioned at management level or higher, a certain level of accuracy in the data collected was assured. Further, respondents had considerable experience both in the field of project management as well as project manager. Participants in this study were divided into five groups: CR (Client/Developer Representatives), PMC (Project Management Consultants), CSC (Construction Supervision Consultants), DC (Design Consultants), and CC (Construction Contractors).

Moreover, more than 80% of the respondents had educational background of civil engineering. Others held professional degrees in mechanical engineering, electrical engineering, commerce, computer sciences, and social sciences. Respondents belonged to over 10 nationalities and spoke more than five different native tongues. Majority of the respondents spoke English as their second language. Most of the respondents (over 75%) were working in joint ventures of project organizations. Few were working in consortiums (12%) and even fewer were working in their parent organizations (11.5%).

5. Analysis of variance (ANOVA)

Internal reliability analysis produced a Cronbach's alpha value of 0.85. This high value confirmed the internal reliability of KPI catalog (Santos, 1999). Analysis of variance (ANOVA) was performed to ascertain if various respondent groups had a general agreement in opinion or not. This comparison of means was carried out by dividing the respondents into different groups based on the following categories:

- Type of organization (client, consultants, and contractors).
- Overall experience in project management.
- Experience as project manager.

Table 4
Nationality and native languages of respondents.

Country of origin	Language of origin	No. of respondents
Czech Republic	Czech	1
England	English	12
Indonesia	Indonesian	1
Japan	Japanese	5
The Netherlands	Dutch	3
New Zealand	English	2
Pakistan	Urdu	1
Thailand	Thai	46
USA	English	4
Venezuela	English	1
Total		76

Table 5
Type of organization.

Type of organization	Frequency
Independent	9
Joint venture	57
Consortium	10

Results of ANOVA in Table 6 show that respondents have no significant difference in their opinion on the rating perceptions of KPIs when they are tested for 'overall experience in project management' and 'experience as project manager'. However, clear difference in rating perceptions are observed when type of the organization is controlled. At confidence level of 90%, statistically significant difference is observed in rating perception for 'one time' (KPI1), 'under budget' (KPI2), and 'doing the right thing' (KPI5). At confidence level of 95%, statistically significant difference in rating perception is notable for 'meets the specifications' (KPI3) as well when type of organization is controlled.

This illustrates that various construction-related stakeholders (client, consultants, and contractors) have substantially different perception for traditional KPIs (such as on time, under budget, and meet the specifications). However they tend to agree on most qualitative measure of project performance (such as safety, minimized disputes, and stakeholders' expectations).

6. *t*-Test results

In order to compare the means between JVs/consortiums and independent firms, *t*-test was carried out.

Table 3
Educational background of respondents.

Background	Civil	Mechanical/electrical	Commerce/economics	Computer	Sciences social sciences
Frequency	61	9	4	1	1
Percent	80.5	11.7	5.2	1.3	1.3

Table 6
ANOVA for different sub-classifications of respondents.

Key performance indicator	Type of organization		Overall experience		Experience as project manager	
	F	Sig.	*F*	Sig.	*F*	Sig.
On time (KPI1)	3.80	.007**	1.13	.349	.22	.949
Under budget (KPI2)	4.06	.005**	1.27	.286	.38	.855
Meets specifications (KPI3)	2.75	.034*	3.26	.010*	1.20	.318
Efficiently (use of resources) (KPI4)	.46	.762	1.23	.301	1.30	.271
Doing the right thing (effectiveness) (KPI5)	3.80	.007**	1.58	.176	1.16	.334
Safety (KPI6)	2.27	.070	.98	.433	1.21	.314
Free from defects (high quality of workmanship) (KPI7)	.22	.923	1.29	.276	1.53	.189
Conforms to stakeholders' expectations (KPI8)	.75	.558	1.09	.371	1.33	.258
Minimized construction aggravation, disputes, and conflicts (KPI9)	.67	.611	1.30	.272	1.27	.284

* $p < .05$.
** $p < .01$.

Table 7
t-Test for professionals working independently and in joint ventures.

Key performance indicator	JV/consortium (67)[a]			Independent firms (9)			*t*-Test	
	Mean	SD	Rank	Mean	SD	Rank	*t*	Sig.
On time	4.67	0.53	1	4.11	0.78	2	−2.79	.007*
Under budget	4.46	0.61	2	3.78	0.83	6	−3.01	.003*
Safety	4.30	0.72	3	3.89	0.93	5	−1.83	.071
Meets specifications	4.25	0.61	4	4.44	0.53	1	−1.57	.120
Efficiently (use of resources)	4.22	0.55	5	3.44	1.01	9	1.14	.257
Doing the right thing (effectiveness)	4.06	0.67	6	3.78	1.30	7	−2.42	.018
Free from defects (high quality of workmanship)	4.01	0.81	7	4.11	0.78	3	.38	.737
Conforms to stakeholders' expectations	3.99	0.73	8	4.11	0.93	4	.47	.638
Minimized construction aggravation, disputes, and conflicts	3.97	0.74	9	3.78	0.67	8	−.74	.461

* $p < .01$ (difference is statistically significant).
[a] No. of respondents.

Results of the *t*-test are shown in Table 7. It can be seen that respondents belonging to firms working independently and those working in joint ventures tend to generally agree about their rating perception of KPIs, except for 'on time' (KPI1) and 'under budget' (KPI2), on which they show statistically significant difference. These results imply that there is insufficient evidence to conclude that professionals working in independent firms perceive KPIs differently from those working in JVs/consortiums.

As for as the difference of perception is concerned for 'on-time' (KPI1) and 'under budget' (KPI2), all organizations working independently were mostly local whereas all JVs/consortiums comprised both local and international participants. There is likelihood that local firms perceive KPIs differently from their international counterparts – as it is obvious from the ranking of KPIs in Table 8. This may be due to a cultural difference between local and international firms. As compared to those working in JVs/consortiums, respondents working in independent organizations may possibly be more concerned about conformance to the specifications, quality of workmanship, and conformance to stakeholders' expectations, as it can also be seen from the ranking of KPIs in Table 8. It should be noted that the results of *t*-test may have limitations due to unequal sample sizes of respondents from JVs/Consortiums (67) and independent firms (9).

7. Ranking of the key performance indicators (KPIs)

Ranking of various KPIs was obtained by computing the means for the overall sample as well as for separate groups of stakeholders. It is evident that all respondents are conscious about time (KPI1), budget (KPI2) and efficient use of resources (KPI4) along with safety (KPI6), and quality (KPI3). Since the Airport was targeted to be opened in September 2005, high ranking of 'on time' is not unexpected. As the project is a high profile symbol in the Thai construction industry and is projected to be a future aviation hub Asia, perception about high quality and budget achievement is also understandable. Overall low ranking of 'minimized construction aggravation, disputes, and conflicts' is rather surprising. However, this may be due to intuitive understanding of the respondents about the Thai culture that is typically inclined towards 'conflict free' work onsite.

There are some noticeable differences between the rankings of KPIs across various stakeholders. For example, 'on-time' (KPI1) is high on the agenda of all stakeholders. 'Under budget' (KPI2) is generally given a priority by all except the client. 'Efficiently' (KPI4) is a main concern for the client and project management consultants whereas 'safety' (KPI6) seems to be more important for design consultants and construction contractors. In accord with their

Table 8
Ranking of key performance indicators.

Description	Overall (76)[a]		Client (7)		PMC (10)		CSC (38)		DC (5)		CC (16)	
	M^*	R^{**}	M	R	M	R	M	R	M	R	M	R
On time	4.61	1	4.00	3	4.60	1	4.55	1	5.00	1	4.88	1
Under budget	4.38	2	3.57	7	4.40	2	4.42	2	4.20	4	4.69	2
Efficiently (use of resources)	4.25	3	4.43	1	4.30	3	4.24	5	4.00	6	4.25	4
Safety	4.24	4	3.57	6	3.90	6	4.37	4	4.60	2	4.31	3
Meets the specifications	4.21	5	3.57	8	4.10	4	4.39	3	4.20	5	4.13	6
Free from defects (high quality of workmanship)	4.03	6	4.00	4	3.90	7	4.05	8	3.80	7	4.13	7
Conforms to stakeholders' expectations	4.00	7	4.14	2	3.90	8	4.11	7	3.60	9	3.88	9
Doing the right thing (effectiveness)	3.99	8	3.14	9	3.90	5	4.16	6	4.40	3	3.88	8
Minimized construction aggravation, disputes, and conflicts	3.95	9	3.71	5	3.90	9	3.92	9	3.80	8	4.19	5

[a] No. of respondents.
* Mean.
** Rank.

role, conformance to the specifications (KPI3) is on preference for construction supervision consultants. Together, all stakeholders seem to value the project completion on time, under budget, with quality according to specifications, and with a due care for safety.

8. Correlation between the KPIs

Correlation test was also run to examine how various KPIs associate with each other. Table 9 shows that all KPIs significantly and strongly correlate with each other except in few instances in which KPI1 (on time), KPI2 (under budget), and KPI3 (according to specifications) do no correlate with some other KPIs. Apart from these exceptions, all KPIs strongly and significantly correlate with each other, showing that they bear strong relationships.

Strong correlations between various KPIs may imply that they are similar to each other (or overlap each other) and hence can be reduced by using factor analysis. However, it should noted that some of these KPIs are quantitative where as others are qualitative in nature. Combining them through factor analysis would not serve any purpose. However, results in Table 9 do show that most of the KPIs are not only interrelated but logically interconnected. For example, safety (KPI6) cannot be achieved unless effectiveness or doing the right thing (KPI5) is not in place. Similarly, minimized construction aggravation and conflicts (KPI9) cannot be achieved unless the project conforms to stakeholders' expectations (KPI8). In other words, these KPIs are inseparable and should not be looked at in isolation from each other. Instead, these KPIs should be seen as various aspects of the same performance measurement model.

9. Discussion of results

Top ranked KPIs are completion 'on time' (KPI1), 'under budget' (KPI2), 'efficiently' (KPI4), 'safety' (KPI6), and 'according to specifications' (KPI3). Therefore, on mega construction projects, especially the case study project, respondents are conscious about the popular 'iron triangle' of construction industry, that is 'completion on time, under budget, and according to specifications'. However, findings in this study show that there is significant concern about efficiency and safety. These results show that the construction stakeholders are starting to think beyond the traditional measures of project performance. Iron triangle is not an inclusive measure of project

Table 9
Correlations among KPIs.

	KPI1	KPI2	KPI3	KPI4	KPI5	KPI6	KPI7	KPI8	KPI9
On time (KPI1)	1								
Under budget (KPI2)	.451**	1							
Meets specifications (KPI3)	.285*	.448**	1						
Efficiently (use of resources) (KPI4)	.311**	.355**	.482**	1					
Doing the right thing (effectiveness) (KPI5)	.354**	.278*	.607**	.505**	1				
Safety (KPI6)	.252*	.344**	.601**	.406**	.648**	1			
Free from defects (high quality of workmanship) (KPI7)	.276*	.105	.444**	.444**	.452**	.523**	1		
Conforms to stakeholders' expectations (KPI8)	.091	.450**	.432**	.425**	.434**	.547**	.446**	1	
Minimized construction aggravation, disputes, and conflicts (KPI9)	.106	.232*	.162	.370**	.345**	.403**	.369**	.440**	1

* Correlation is significant at the 0.05 level 2-tailed.
** Correlation is significant at the 0.01 level 2-tailed.

performance anymore. This research suggests that Fig. 1 should be considered as the new measure of performance on large construction projects. There are three levels at which KPIs should be looked at. Issues related to time, budget, and quality are at the core of project performance evaluation – or what is conventionally known as the iron triangle of performance evaluation.

However, these are not the only issues based on which the success of a project should be evaluated. Issues related to safety, efficiency, and precision (or 'doing the right thing') are equally important for a project to be on-time, on-budget, and according to specifications. For example, it is questionable to conceive a project to be successful if it does not offer safe working conditions to the workers. Similarly, it is unlikely to achieve the deadlines if the tasks are not accomplished with efficiency and precision. 'According to specifications' (KPI3) and 'doing the right thing' (KPI5) largely fall under the discussion on quality. As far as construction is concerned, the focus on quality management given only the construction stage and on the product quality, as Toakley and Marosszeky (2003) rightly point out. While it is important to ensure quality during construction stage and on the product, it is equally significant to achieve quality during early stages of the project (such as analysis, planning, and design). Therefore, it is essential that attention is paid to a total the attainment of total quality during the project life-cycle (Toakley and Marosszeky, 2003).

On similar lines, Rosenfeld (2009) reaffirms that investing in quality is a worthy strategy and leads to several benefits. His recent research shows that the ratio of the direct benefits to the investment – in terms of savings on internal and external failures that might occur in the absence of quality attainment procedures – is 2:1 or more. These findings are not only very encouraging but also demonstrate the value that the investment on quality attainment can generate.

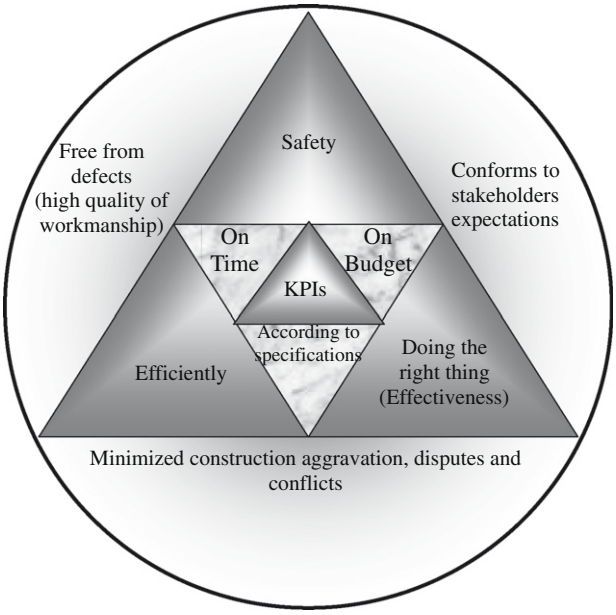

Fig. 1. Performance measurement criteria for mega projects.

At the last and final level, issues related to the stakeholders' satisfaction, construction conflicts and disputes, and reduced defects (high quality of workmanship) must be considered in the framework of performance evaluation. It is very common for construction projects to suffer from delays and budget overruns due to disputes among the parties. Including many other issues, these disputes are often due to dissatisfaction of various stakeholders with certain aspects of the project. Similarly, disputes and conflicts also arise when there is poor quality of the finished work. Disputes in construction projects sometime lead to excessive litigation, resulting in loss of time, money, and various intangible social benefits that the construction facility was to offer. Therefore, a conscious effort must be made to reduce the possibility of any conflicts of disputes.

Construction of the Heathrow Terminal 5 is a recent example in which a conscious effort was made by the client (BAA in this case) to prevent the conflicts as much as possible by recognizing and accepting that it took the ultimate responsibility for risk. This was done by an integrated risk management approach which essentially comprised three main aspects, as noted by Williams (2008) in his speech at the IMIA-2008 conference:

1. BAA focused on selecting the best people to work as an integrated team (T5 Team) to work towards the project goals with a problem solving approach. Involvement of an HR specialist, support of the top management, and focus on quality in execution made it possible for the team to work towards a single goal.
2. BAA adopted an innovative procurement strategy in which suppliers were given a guaranteed margin based on an open-book relationship. A shared incentive approach was also adopted to reward exceptional performance. In return, BAA asked the suppliers to provide a standard no less than best practice.
3. BAA owned all the risk and to manage and mitigate the risks it put in place an innovative framework – such as integrated use of risk registers, continuous involvement and knowledge building of participants through workshops, and involvement of insurers from the outset.

In order to avoid conflicts arising from logistics and interface management, "4-D" construction planning was employed on the T5 project. In 4-D planning, time is the fourth dimension with CAD data (2-D or 3-D), creating a real-time graphical simulation of planned works (Toakley and Marosszeky, 2003). Use of virtual modeling helped prevent conflicts and delays by enhancing the coordination across contractors and detecting clashes before they would actually occur on site.

Results in this study show that the perception of some KPIs does differ across various construction stakeholders. This finding is plausible given different vested interests of various stakeholders involved in the project. However,

professionals do not differ significantly in their perception about KPIs across various levels of experience. This finding is different from that of Cox et al. (2003) who ascertained that the perceptions of KPIs was different among professionals based upon their number of years of experience. This difference of finding is possibly due to different context and target population used in both studies. However, ranking of KPIs in this study resonatee with the findings of the study of Cox et al. (2003), which found that the KPIs consistently perceived as being highly significant include quality control, on-time completion, cost, and safety. These findings also strengthen the viewpoint presented in earlier works (for example, Savindo et al., 1992; Munns and Bjeirmi, 1996; Turner, 1993) which advocates that the performance of a project should be measured beyond its 'on-time' and 'under-budget' completion.

It can be seen from Fig. 1 that three layers at which the KPIs have been placed are closely connected to each other. In order to achieve the KPIs at the core (on-time, on-budget, and according to specifications), there must be an effort put to achieve safety, efficiency, and effectiveness/precision. Similarly, the KPIs at the core cannot be achieved if the KPIs at the periphery are not constantly monitored. Therefore, the iron triangle may stand at its position for measuring the performance of projects, yet it can only be achieved if due attention is given to other the KPIs in the outer triangle and at the periphery of the circle.

In the recent years, there have been many advances in field of project performance management. Norrie and Walker (2004), for example, propose a new perspective of project performance management; that is projects should be completed on-time, on-budget, on-quality, and more importantly, on-strategy. One may argue that 'sustainability' should also be at the centre of project performance management framework. These developments show that the perception of project performance is changing fast and best performing companies are beginning to take a strategic stance in measuring the performance of their projects. In a world of hyper competition, projects are no longer seen as tasks or means to survival. Instead, projects are growingly seen as powerful strategic weapons that organizations use to enhance their competitiveness, win the market place, compete in the dynamic and furiously commercial world, and create value for their clients and other stakeholders (Shenhar, 2004). In other words, the mindset of project performance management must transform from operational/functional nature to more of strategy-focused.

10. Directions for future research

Among various KPIs discussed in the current study, it is possible to measure some KPIs more objectively as they are easily quantifiable – such as 'on-time' and 'on-budget'. Whereas KPIs like 'minimized construction aggravation, disputes and conflicts' is not easily measurable because of its qualitative nature. However, as Sohail and Baldwin (2004) suggest, combining both quantitative as well as qualitative information can help establish a benchmarking system for which further research should be conducted. Therefore, more future research is needed that may focus on establishing a comprehensive benchmarking system to measure performance on large development projects in the public sector. Future research may also focus on integrating KPIs related to operational issues (such as time, cost, and quality), life-cycle issues (such as maintainability, energy consumption, and satisfaction of the users etc.), strategic issues (such as inter-organizational co-operation, organizational learning etc.), and socio-economic issues (such as social and human development in the area). Another direction in which the future research can progress is to establish a clear link between critical success factors (CSFs) and KPIs. More work is needed to understand how effective implementation of CSFs translates into the attainment of desired KPIs.

It should also be noted that the case study project employed traditional procurement strategy of design-bid-build. However, it can be anticipated that the participants will have a different perception about performance of a project if a different procurement strategy has been adopted. Therefore, future works on KPIs may focus on projects with different procurement systems such as Public–Private-Partnerships (PPP), Build-Operate-Transfer (BOT), and Design-Build (DB). More research can be carried out to establish more objective indices which can encompass the issues of quality, workmanship, maintainability, and energy efficiency of the built facilities. Issues related to sustainable buildings need to be examined in further detail in relation with project performance measurement. Finally, more research should be conducted by including the facility users (such as building residents or office users) to examine how they perceive the performance of a facility after it has been built.

11. Conclusions

Performance measurement is one of the important aspects of project management. As there are different needs and different goals of any given project, performance measurement should also be tailored for each project. However, a general framework can be used as a guide to measure the success of a project at macro and micro levels. Iron triangle (on time, under budget, according to specifications) has been widely accepted criteria during last couple of decades. However, with shifting functions of buildings, changing demands of users, evolving environmental regulations, the same old-fashioned performance criteria can no more be the sole determinant of project success. Success of future projects will be increasingly measured on the criteria of strategy, sustainability, and safety. Future buildings and infrastructure will be evaluated based on their operational flexibility, maintainability, energy efficiency, sustainability, and contribution to the overall well-being of their end users. Therefore, future

frameworks of project performance measurement need to be more comprehensive and should include not only the quantitative and objective criteria but also more subjective and qualitative criteria. Modern needs, future demands, expectations of the stakeholders, and regulations must also be incorporated into an inclusive index that can explain if the project is a successful public facility or just another mass of concrete and steel.

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