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Development of performance metrics for phase-based capital project benchmarking

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Abstract

Despite various research efforts focusing on the development of an effective measurement system, most project performance metrics were designed for post evaluation of processes and practices after project completion. This paper presents performance metrics tailored to phase-based benchmarking, which can be utilized as both leading and lagging indicators. Built upon industry experts' input and an extensive review of existing metrics, a framework for performance metrics was developed to evaluate performance outcomes for five major phases; front end planning/programming, design/engineering, procurement, construction, and startup/commissioning. Within this framework, phase-wise and phase-specific metrics were created under the categories of cost, schedule, efficiency, staffing, procurement, and safety performance. The results show that the framework and metrics are effective for the evaluation of project performance throughout capital project delivery. By employing the benchmarking process during the course of the project, industry practitioners can improve project performance and develop proactive strategies for subsequent phases.

Keywords: Performance measurement; Performance metric; Phase-based benchmarking; Project management; 10–10 program

1. Introduction

Performance metrics are an essential element of capital project benchmarking. Without a doubt, the use of effective performance metrics is a key to successful benchmarking of capital projects. Several benchmarking studies have developed effective measurements to evaluate various performance outcomes (Chan and Chan, 2004; Costa et al., 2006; Hwang et al., 2008; McCabe, 2008; Beatham et al., 2004; Suk et al., 2012; Yeung et al., 2013). Most benchmarking methods adopt a holistic evaluation approach to measuring performance outcomes at the project level, focusing on processes and practices after project completion. Therefore, benchmarking benefits are usually only obtainable during post evaluation of a project, in other words, in preparation for future projects. Due to the continued fluctuation of the global economy and rapid change in the business environment, construction owners and contractors require a more effective and flexible measurement tool to evaluate performance during the course of an on-going project, and to align their business strategies with project management (Yun et al., 2012).

In response to the increasing demand for effective performance measurement, the Construction Industry Institute (CII) initiated a new benchmarking program called the 10–10 Program, which adopts a concept of performance measurement at the phase level. The CII is a leading research organization, which creates and implements research-based knowledge that measurably improve the effectiveness and sustainability of capital facilities delivery (CII, 2015). The objectives of this paper are (1) to develop new performance metrics tailored to phase-based benchmarking for evaluating processes, practices, and the organization itself at the phase level, (2) to validate the

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newly designed metrics based on industry experts' opinions and collected data, (3) to discuss considerations to normalize cost, quantity, and capacity for appropriate comparison of absolute performance metrics, and finally, (4) to discuss the applicability of the metrics for phase-based benchmarking of capital projects. The developed metrics can be used as early warning indicators to enable construction executives and project managers to efficiently measure project performance at the phase-level, get more reliable norms of phase-level performance for meaningful comparison, and establish proactive and effective strategies for improving performance in subsequent phases or future projects.

2. Performance metrics in benchmarking

Over the last several years, many research efforts have continued to develop adequate metrics for evaluating project performance in the construction industry (Chan and Chan, 2004; Costa et al., 2006; Hwang et al., 2008; McCabe, 2008; Beatham et al., 2004; Suk et al., 2012; Yeung et al., 2013). An effective measurement system is paramount for upper management and project professionals to identify critical performance outcomes at the project level for their construction business (Cox et al., 2003). Prior benchmarking models have adopted ex-post evaluation which mainly provides benchmarking results after project completion (Yeung et al., 2013). Most performance metrics in use today in benchmarking studies and models report mainly lagging indicators. Therefore, these benchmarking models are not able to fully recognize performance variation within each phase of capital project delivery (Beatham et al., 2004; Costa et al., 2006).

A number of performance studies have selected key performance indicators (KPIs) among commonly accepted performance metrics in order to evaluate performance outcomes of capital projects at the project level. Cox et al. (2003) examined quantitative and qualitative performance metrics typically used in the construction industry, and found six KPIs which are highly significant to construction executives and project managers. The six KPIs derived from their study are quality control, on-time completion, cost, safety, cost per unit, and units per man-hour (Cox et al., 2003). Yeung et al. (2007) developed the partnering performance index (PPI) which is a weighted composite performance index based on seven KPIs using the Delphi method. The PPI consists of time, cost, top management commitment, quality, trust and respect, effective communication, and innovation and improvement (Yeung et al., 2007). Luu et al. (2008) identified nine KPIs for improving management performance of large construction contractors, which contains construction cost, construction time, customer satisfaction, quality management system, project team, change management, material management, and labor safety management (Luu et al., 2008). Skibniewski and Ghosh (2009) listed construction cost, construction time, predictability of cost and time, defects, client satisfaction, safety, and profitability and productivity as nine critical KPIs applicable to construction firms. Rankin et al. (2008) developed performance metrics that were targeted to apply to the Canadian construction industry in terms of cost, time, quality, safety, scope, innovation, and sustainability. Among the metrics in particular, some capacity-based metrics were designed such as cost per unit and time per unit (Rankin et al., 2008). Ling et al. (2009) developed key project management practices for metrics found to substantially impact on project performance of Singaporean construction firms in China. The study measured project performance by a seven-point scale with regard to budget, schedule, quality, owner satisfaction, profitability, and public satisfaction. Swarup et al. (2011) noted performance metrics influencing on project goals for sustainable, high-performance buildings in terms of schedule, cost, quality, and post-occupancy evaluation from the owner's perspective (Swarup et al., 2011). Almahmoud et al. (2012) examined the linkage of project health to project performance indicators through multiple case studies of construction projects in Saudi Arabia. They used six KPIs obtained from Project Management Office progress reports including cost, time, scope, quality, safety, and satisfaction for project diagnosis (Almahmoud et al., 2012). Yeung et al. (2013) developed a benchmarking model for construction projects in Hong Kong through detecting KPIs based on the composite performance index using ten KPIs including safety, cost, time, quality, client's satisfaction, communication effectiveness, end user's satisfaction, planning effectiveness, functionality, and environmental performance. The KPIs, which were drawn from the previous research studies, are summarized in Table 1. Cost, time, and quality indicators are identified from all of the studies, and safety is also commonly included in most of studies. In addition, some researchers considered unique KPIs such as customer satisfaction, change (scope) management, productivity, and so forth.

Some researchers have suggested performance metrics should be applied to evaluate performance outcomes to specific project phases in construction projects (Haponava and Al-Jibouri, 2009; Shohet, 2006; Wegelius-Lehtonen, 2001). Haponava and Al-Jibouri (2009) proposed KPIs tailored to the front end planning phase including client management, alignment of project goals, risk management, project plan development, stakeholders' involvement and communication, management of scope changes. Weglius-Lehtonen (2001) developed performance measurement tailored to construction logistics in the procurement phase including improvement measures and monitoring measures. The improvement measures were developed based on the theory of activity-based costing and the theory of controllability engineering and monitoring metrics including efficient project time, value added, subcontracting percentage, the number of invoices per day, amount of invoices, disposal costs, reply percentage of tenders, and amount of changes in subcontract (Wegelius-Lehtonen, 2001). Shohet (2006) identified phase-specific performance measurements for hospital facilities during operations and maintenance. The performance metrics for hospital operations and maintenance consist of eleven KPIs in four categories to include: 1) asset development metrics including built area, occupancy of the asset, and facility age; 2) organization and management metrics including number of employees per built area, scope of facility management outsourcing, management span of control, and maintenance organizational structure; 3) performance management metrics including a building performance indicator designed to evaluate the overall state of