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PROJECT PERFORMANCE INDEX FOR CAPITAL INTENSIVE CONSTRUCTION PROJECTS

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Holistic construction performance measure has been an elusive and highly sought-after goal. The stochastic nature of construction processes and the number of stakeholders involved in these processes have added to the complexity of the problem. Large-scale infrastructure projects produce big data in form of actual site parameters, safety data, risk analysis data, cost data, financial data, quality assurance data and procurement data. This research aims at developing a project performance index. The factors influencing project performance have been grouped together as Critical Success Factors (CSFs) then through survey and expert opinions, relative weights have been collected for these factors. The factors and weights have been modeled through Regression Technique and validated through analytical and mathematical methods. The developed index will benefit the academic researchers and industry practitioners to assess the performance of the project and to increase the efficiency of project performance.

Keywords: Critical success factors, Construction project, Project performance, Schedule, Cost, Quality, Safety, KPI, Balanced scorecard.

1 INTRODUCTION

Construction projects are prone to time delays and cost overruns. (Mirza and Ehsan 2017). There are several measures that have been devised to gauge project performance based on numerous studies of critical project success factors, but these are mostly quantitative factors that have been calculated based on formulae developed by researchers. Project complexity factors have been characterized in the past in five broad categories: time/schedule, scope, cost/budget, quality, resources and risk (Mirza and Ehsan 2017)

The construction industry has come a long way in incorporating more advance technology on and off the site. There is an influx of newer information systems and more robust reporting systems but the major hurdle still happens to be reluctance of project managers to share data. Most companies have measuring systems to monitor their performance and while companies are entitled to their privacy, a generic rating system built for a specific industry can go a long way in improving efficiency – this is the aim of this research. Even with the intra-company measures, staff and executives have difficulty triaging the available factors to come up with an effective action plan.

2 BACKGROUND

Nguyen *et al.* (2013) performed an exploratory analysis by listing project success measures from literature published in the past decade or so. Though the list isn't comprehensive it provides a great start at how researchers have looked at measuring project success in the past. As a summary of the findings of Nguyen *et al.* (2013) the following areas were identified that success measures may be categorized into:

- Time Performance
- Cost Performance
- Quality Performance
- Customer Satisfaction
- Safety Performance
- Organizational Objectives

Several quantitative measures can be devised to measure the performance of a project in the above-mentioned areas. Alternatively, Young and Poon (2013) researched the effect on project performance of 'Top Management Support' – a qualitative factor. Maqbool *et al.* (2017) focused their efforts on studying the importance of leadership traits such as emotional intelligence, competency, and of different leadership styles and their impact on project performance. There is merit to both qualitative and quantitative factors. One of the major pursuits of this paper is to select factors from a mix of qualitative and quantitative factors and to identify factors that may have been overlooked because they couldn't be described quantitatively and, subsequently, measure their contribution towards project success.

2.1 Critical Success Factors

Critical Success Factors (CSFs) are defined by Toor and Ogunlana (2009) as, "elements which significantly contribute to, and are vital for, the success of a project". In theory, CSFs have been employed by several industries – Medicine, Manufacturing, IT and Construction. Pinto and Slevin (1987) are among the first researchers to classify factors as 'critical success factors' in an attempt to quantify the performance of construction projects.

Other researchers have also compiled lists of critical success factors and categorized them into roughly the same areas as mentioned previously under project success areas (Belassi and Tukel 1996, Fortune and White 2006). There has been a marked shift in research focus recently; where construction performance was measured in terms of time, cost, quality and safety (de Wit 1988, Pinto and Slevin 1987, Sanvido *et al.* 1992) there is a move towards quantifying the effect of human aspects such as emotional intelligence (Maqbool *et al.* 2017), upper-management support (Young and Poon 2013), and clear definition of goals (Toor and Ogunlana 2009).

2.2 Existing Project Performance Metrics

The Project Excellence (PE) model used by the German Project Management Association is one of the earliest nation-wide performance measurement models (Westerveld 2003). The model was derived from acceptable industry practices such as those developed by the EFQM (European Foundation for Quality Management) and the PDCA (Plan-Do-Check-Act) cycle of continuous development.

The Balanced Scorecard (BSC) is another popular performance measurement metric devised by the Harvard Business School (HBS) Professor Mr. Robert Kaplan and Renaissance Solutions President, David Norton. A versatile metric used across various industries, it identifies "leading and lagging" measures for various factors affecting a process to ascertain whether the process is achieving its desired goal or not. Kagioglou *et al.* (2001) proposed the "Performance Measurement Process (conceptual) Framework (PMPF)" inspired by the Balanced Scorecard method as a metric tailored for the construction industry. The European KPI system and Canadian metric program are both similar performance measurement models built for construction companies operating within these regions (Bassioni *et al.* 2004, Costa *et al.* 2007, Nasir *et al.* 2012, Rankin *et al.* 2008).

KPIs are a part of the Constructing Excellence Productivity program and were designed in 2003 as an initiative to benchmark construction performance in the UK. The process involved extensive reviews of construction projects by a panel of experts that rated the project on a comprehensive scale of factors. The KPI was implemented as a national program with companies volunteering to participate and making use of the results for planning their own projects.

With the aim to holistically measure construction project performance, the first step is to decide on all the spheres of influence that may contribute towards that performance. The methodology employed by the researcher is somewhat similar to Elwakil's (2017) investigation of organizational performance index. Namely, shortlisting success factors from existing literature, spreading them across functional units in a project and performing mathematical modelling to determine their ideal weightages in calculating the performance index. The modelling approach will be tailored according to the groups of factors out of the available tools such as analytical hierarchy process, fuzzy modelling, and/or multiple linear regression. The mathematical models will be validated against data collected from actual projects and their score on an industry-accepted metric like the ones described in the next section.

3 METHODOLOGY

The steps followed in this research are summarized in a step-wise fashion as below:

- The process begins with identifying and shortlisting factors that contribute to the performance assessment of construction projects. This step has been accomplished by undertaking a review of relevant literature in the body of knowledge. Both qualitative and quantitative factors have been documented for further analysis.
- The factors are documented against their sources and clustered under broad areas in Table 1 for better analysis. This list has been subjected to further analysis to yield a list of Critical Success Factors (CSFs). The proposed Project Performance Index (PPI) takes these Critical Success Factors as primary inputs to the model.
- The process of shortlisting has been accomplished by designing a questionnaire aimed at deducing the impact of these factors as estimated by industry professionals. The survey also notes the respondent's experience, designation and organization to add perspective to the response. More about the survey design has been discussed in the section on Survey Design.
- Simultaneously, a database has been started of performance factors available in the industry to assess performance of existing projects. This will serve as a validation tool for the Project Performance Index developed as part of this research and a way to translate industry generated data as inputs to this research model.
- Responses from the survey shall be subjected to further mathematical analysis (Multiple Linear Regression/Analytical Hierarchy Process) to gain insight on weights of Critical Success Factors, correlation between factors and interaction among factors.

3.1 CSF Matrix

Work on CSFs available in the literature is summarized in Table 1.

Table 1. Critical Success Factors shortlisted from literature review.

S no.	Factor	Source
1	Top Management Support	(Young and Poon 2013), (Martin 1976), (Cleland and King 1983), (Toor and Ogunlana 2009), (Pinto and Slevin 1987), (Morris and Hough 1987), (Fortune and White 2006)
2	Regular Client Involvement	(Young and Poon 2013), (Cleland and King 1983), (Toor and Ogunlana 2009), (Sayles and Chandler 1971), (Pinto and Slevin 1987), (Fortune and White 2006)
3	Clear Statement of Requirements	(Young and Poon 2013), (Toor and Ogunlana 2009), (Cleland and King 1983)
4	Proper Planning and Project Controls	(Young and Poon 2013), (Toor and Ogunlana 2009), (Martin 1976), (Cleland and King 1983), (Fortune and White 2006), (Locke 1984), (Cleland and King 1983), (Sayles and Chandler 1971), (Baker *et al.* 1983), (Morris and Hough 1987)
5	Smaller Project Milestones	(Young and Poon 2013), (Martin 1976)
6	Realistic Expectations	(Young and Poon 2013), (Toor and Ogunlana 2009)
7	Clear Vision and Objectives	(Young and Poon 2013), (Toor and Ogunlana 2009), (Martin 1976), (Fortune and White 2006) , (Locke 1984), (Baker *et al.* 1983), (Morris and Hough 1987)
8	Team Composition and Competency	(Young and Poon 2013), (Toor and Ogunlana 2009), (Martin 1976), (Fortune and White 2006), (Cleland and King 1983), (Baker *et al.* 1983), (Pinto and Slevin 1987)
9	Change Management	(Young and Poon 2013), (Toor and Ogunlana 2009), (Fortune and White 2006)
10	Project Manager Competence	(Toor and Ogunlana 2009), (Fortune and White 2006), (Locke 1984), (Sayles and Chandler 1971), (Baker *et al.* 1983)
11	Contractors and Sub Contractors	(Toor and Ogunlana, 2009), (Fortune and White 2006)
12	IT Support	(Toor and Ogunlana 2009), (Fortune and White 2006), (Cleland and King 1983)
13	Monitoring and Feedback	(Toor and Ogunlana 2009), (Fortune and White 2006), (Cleland and King 1983), (Sayles and Chandler 1971), (Morris and Hough 1987)
14	Stakeholder Support and Involvement	(Toor and Ogunlana 2009)
15	Continued Financial Support	(Young and Poon 2013), (Fortune and White 2006), (Martin 1976), (Cleland and King 1983), (Baker *et al.* 1983), (Pinto and Slevin 1987), (Morris and Hough 1987)
16	Communication between all parties	(Toor and Ogunlana 2009), (Martin 1976), (Locke 1984), (Pinto and Slevin 1987)
17	Risk Management	(Fortune and White 2006)
18	Staff Training	(Fortune and White 2006)

3.2 Data Collection

The outputs from the Model are validated by the Average Validity Percentage (AVP) and Average Invalidity Percentage (AIP) as a first layer of validation. The second layer is to validate against the database of industry-accepted performance assessment database.

4 CONCLUSIONS

A Project Performance Assessment Model (PPAM) for construction projects shall be developed using a Hierarchical Fuzzy Expert System (method still under consideration).

The outputs from the Model will be validated by the Average Validity Percentage (AVP) and Average Invalidity Percentage (AIP) as a first layer of validation. The second layer will be to validate against the database of industry-accepted performance assessment database. The researcher is currently in the process of data collection and hopes to deduce conclusions in the coming months.

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