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10-10 Project Campaign: 10 Input Measures Influencing Project Outcomes

Jiyong Choi[1], Youngcheol Kang[2], Sungmin Yun[3], Stephen Mulva[4], and Daniel Oliveira[5]

Abstract: This paper presents 10 input measures influencing project outcomes. Construction Industry Institute (CII), a consortium of more than 130 project owner and contractor companies, has collected project-level data for over 20 years. Recently, CII has developed a new system measuring project-level performance and factors presumably influencing project performance. The system, called 10-10, collects data for 10 input and 10 output measures for capital projects. The input measures include planning, organizing, leading, controlling, design efficiency, human resources, quality, sustainability, supply chain, and safety. This paper provides theoretical background for these measures. Although the input measures have been known to impact on project outcomes such as cost and schedule, there has been no study quantitatively evaluating how they are operated in the construction industry. This study contributes to revealing the current status of their uses, which will be helpful in establishing strategies improving construction project performance.

Keywords: Benchmarking, Performance Measurement, 10-10, Leading Indicator, and Input Measure

I. INTRODUCTION

Over the past two decades, Construction Industry Institute (CII) has been initiated various performance assessment programs to evaluate an organization's performance against recognized leaders to determine best practices leading to better performance [1]. Existing benchmarking programs, however, have focused on assessing project-level outcomes rather than phase-level outcomes because they collect project data once projects are complete [2].

CII has recently developed a new phase-based benchmarking program, called 10-10 Program. The program collects data at the end of each project phase and project performance are evaluated through 10 input and 10 output measures [3]. This new benchmarking approach enables projects to identify impending problems of a project and then to take proactive strategies for the subsequent phase of in-progress projects [1]. The benchmarks thus allow a project manager to determine if a phase is executed successfully or a project is proceeding on target [3].

This paper focuses on input measures as leading indicators employed in the 10-10 Program. Having defined as crucial measurements of processes, activities, and conditions predicting future results [1], ten input measures are identified as leading indicators for measuring project management input. The ten input measures consist of planning, organizing, leading, controlling, design efficiency, human resources, quality, sustainability, supply chain, and safety. The input measures are categorized into two groups: basic management measures and construction-specific measures. Planning, organizing, leading, and controlling (POLC) have been recognized as basic management measures for evaluating fundamental functions substantially influencing project success. The remaining six measures also have been recognized as construction-specific measures to assess practice uses for successful delivery of construction projects. Although these input measures have been known to influence project outcomes such as cost and schedule, no empirical evidence exists to quantitatively evaluate how they actually work in construction projects.

This paper provides theoretical background for identifying the ten input measures evaluating project management inputs through capital project delivery. To achieve this research goal, a wide range of literature addressing critical success factors and their impact on project outcomes was thoroughly reviewed. In addition, issues and studies associated with the ten input measures adopted in the 10-10 Program are then discussed.

II. BASIC MANAGEMENT MEASURES

POLC have been recognized as four major important business management functions substantially influencing project success. Table 1 summarizes definitions of each function from management books.

TABLE 1
DEFINITIONS OF PLANNING, ORGANIZING, LEADING, AND CONTROLLING

Function	Definition	Reference
Planning	The work a manager performs to predetermine a course of action.	[4,5]
Organizing	The work a manager performs to arrange and relate the work to be done so people can perform it most effectively.	[4,6]
Leading	The work a manager performs to cause people to take effective action.	[4,6,7]
Controlling	The work a manager performs to assess and regulate work in progress and completed.	[4,7]

These functions, as one framework, have been used to classify managers' activities for achieving organizational goals [8]. In addition, these are core functions for project management [9]. The following sub-sections describe the relationship between each function and construction project performance.

A. Planning

In construction projects, the objective of planning is to complete a prescribed amount of work within a fixed time,

[1] Graduate Research Assistant, University of Texas at Austin, 3925 West Breaker Lane (R4500), Austin, TX, USA, jaychoi@utexas.edu
[2] Assistant Professor, University of Seoul, 163 Seoul siripdae-ro, Dongdaemun-gu, Seoul, South Korea, ykang0123@uos.ac.kr*
[3] Postdoctoral Fellow, Construction Industry Institute, 3925 West Breaker Lane (R4500), Austin, TX, USA, sungmin.yun@cii.utexas.edu
[4] Associate Director, Construction Industry Institute, 3925 West Breaker Lane (R4500), Austin, TX, USA, smulva@cii.utexas.edu
[5] Research Associate, Construction Industry Institute, 3925 West Breaker Lane (R4500), Austin, TX, USA, daniel.oliveira@cii.utexas.edu

at a previously estimated cost, and to specified standards of quality by pre-defining a method and course of tasks [10]. A number of literature reported that effective planning on capital projects leads to improved performance in terms of cost, schedule, and operational characteristics [11–15]. Hamilton and Gibson [11] reported that pre-project planning, a process of developing sufficient strategic information to maximize the opportunity for a project success, positively impacts project performance by enhancing the cost and schedule performance. The planning carried out during project execution, as a key implementation for a project's success, helps to anticipate and overcome possible field problems in advance [12]. It allows to provide solutions to current problems and to meet overall project objectives. Hwang and Lim [16] also noted that planning helps develop and identify known or key critical restraints and interfaces, thereby reducing the chance of unexpected occurrences that threaten project progress.

B. Organizing

In today's complex construction projects, project success depends on effective multidisciplinary collaborations of people from different organizations [17]. Since people are the most valuable asset of a construction project requiring multiple skills and judgment [18], motivation, commitment, and cooperation of people on a project are critical to the successful project execution [19]. In response to performance improvement demands, research studies about aligning project teams and organizations successfully has significantly increased over recent years [20–25]. Considering complex nature of construction project, Baiden and Price [21] argued that project teams having collaborative culture and aligned objectives have significant potential for increasing productivity and frequently result in considerable performance improvement. They also emphasized that appropriate organizing efforts enable complimentary use of available skills, highly integrated teamwork to achieve project success. Albanese [26] reported that significant improvements in project results can result from organizational integrations.

C. Leading

Senior management of a project should be effective in motivating the project team to achieve optimal project outcomes. As construction projects require team efforts, leadership has been shown to be a critical factor for a successful project delivery in several studies [17,27–30]. Thamhain [17] reported that project team performance is mainly derived from organizational process controlled by senior management, which largely affects the team in terms of organizational stability, stability of organizational goals, objectives and priorities. Dainty et al. [27] emphasized that leadership as the roles of project managers, is one of critical parameters influencing project success by examining the views of members of project teams and other organizational stakeholders through a series of focus groups. Odusami et al. [29] noted that there is significant relationship between project leader's qualification and leadership style, and overall project performance. The leader behaviour such as communicating project goals, setting high standards and expectations is strongly associated with perceptions of team and project performance and with cost growth and schedule growth [28].

D. Controlling

The aim of project control for construction projects is to ensure that projects finish on time, within budget and achieve other project objectives [31]. The project control deals with observing and reporting on actual performance against expected and thus taking action to shape future events with the aim of accomplishing what has been initially planned [32–34]. It is a major factor in the success of the project at hand and the planning of future projects. There have been a number of research studies asserting the importance of project control, and methods, systems, or tools for better control, mostly focusing on critical project outcomes such as cost [35–38], schedule [39–43], and quality [44–47]. Effective project controls are essential in administering the fundamental project delivery elements of time, cost, risk, and change [48]. Good project control has the capability to reveal trends toward schedule or cost overruns, which facilitates successful project management and reduces risk [16]. Having recognized the importance of proactive project control, strategic performance assessment tools are developed such as the Balanced Score Card [49] and the Project Health Indicator (PHI) [50].

III. CONSTRUICTION-SPECIFIC MEASURES

This section focuses on six construction-specific measures significantly considered as important factors in construction projects. The construction-specific measures are addressed based on practical needs of industry practitioners in the field, while POLC are main interests of upper management such as executives or senior managers in a construction business organization.

A. Design Efficiency

Effective design contributes to enhancing project value [51], which leads to project performance improvement [52]. In the meantime, optimizing design should consider efficiency of design process as well as effectiveness of design quality. The design efficiency is to achieve maximum capacity of production or facility based on the use of appropriate amount of material quantities to be installed with minimum cost. The design efficiency relates to overdesign or inefficient design in terms of the capacity of a facility being built. Waste and inefficiencies of design complicate construction and add to total project costs [53]. Overdesign can be reflected by the amount of oversized members and over specified materials [53]. A large amount of over-specified materials and/or oversized members is unnecessarily costly, indicating an ineffective design. Schedule constraints may sometimes dictate that member size and material specification be selected quickly, but a design containing a disproportionate amount of material waste or containing much greater amount or higher quality of materials than needed, are rated inefficient designs [53].

In summary, design efficiency is more comprehensive point of view of design management to achieve capacity of facility considering management input such as design/engineering teams, material quantities to be installed, and design and construction costs. Although no attempt has made to examine the quantitative relationship between design efficiency and performance outcomes, cost, schedule, and quality benefits can be anticipated when design is made efficiently and effectively.

B. Human Resources

Although construction industry is one of the most labour-intensive industries, human resource issues have not been paid attention adequately [54]. As the construction industry is considered to be one of the most dynamic and complex industrial environments [55], project management activities needs to devote a significant amount of skill, knowledge and attention to human resources to be effective in today's highly competitive environment. Managing people effectively influences project outcomes. The importance of training in project management context is widely reported in the literature [55–57]. Tabassi et al. [55] underlined that human resource issues such as unqualified staff, inadequate training, inexperienced management are one of major causes of project failures. Therefore, critical human resource issues in the construction industry are to make appropriate staffing to allocate qualified staffs in the right place at the right timing, to train them properly, and to minimize amount of staff turnover during execution. However, the human resource issues and practices to solve the issues have not been fully addressed in the construction research.

C. Quality

Quality is one of the fundamental objectives in construction project management. Quality can be defined as achieving the legal, aesthetic and functional requirements of construction project [58]. Therefore, quality can be measured if the project team is strictly confirming to project requirements in terms of legal, aesthetic, and functional requirements requested by an owner. In the construction industry, quality is defined as the totality of features required by a product or services to satisfy a given need; fitness for purpose [45]. 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 planning and design) [59]. Therefore, quality should be taken into account for the whole project life cycle. In line with that, Rosenfeld [46] affirmed 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 of investment on quality. Quality management has still been one of critical management practices and needs to keep focused to achieve goals of a construction project.

D. Sustainability

Sustainability has been a major driver changing construction projects. In the U.S., green building market had increased at least five times in the period of 2005 to 2010 [60]. New laws and regulations have been released to enforce green construction. There have been few studies investigating the relationship between sustainability and construction project performance. If comparing green and conventional projects, it has been reported that green projects are more costly than conventional projects. Kats et al. [61] reported that the average premium for green buildings is approximately 2%. Due to the regulations from sustainability certification programs such as Leadership in Energy and Environmental Design (LEED), green projects tend to be more complicated. This causes cost overruns, project delays, and productivity losses [62,63]. By analysing 123 project-level data, Kang et al. [64] found that green projects with superior cost performance tend to involve more planning than conventional projects. In summary, sustainability has changed construction projects significantly. Although some studies investigated green projects' performance, the current body of knowledge lacks the quantitative relationship between sustainability and project performance and practice delivering green projects successfully.

E. Supply Chain

As a construction project delivery of construction project becomes more complicated and globalized, supply chain management has been more significant. To maximize profits, companies tend to procure materials and equipment from the global market, which leads to more complex supply chain. There are many studies highlighting the importance of supply chain management to achieve competitive advantage in the current global construction market [65, 66]. However, research about this topic has been still relatively new in the construction industry [67]. It is necessary to investigate how supply chain influences project performance in the construction industry. Unfortunately, the current body of knowledge lacks such a relationship.

F. Safety

Construction industry has been recognized as one of the most dangerous occupations. In the U.S. in the period of 1992 to 2010, over 20,000 workers had lost their lives from occupational injuries [68]. In addition to the numerous social problems and economic burden to workers, accidents have negative impacts on construction project performance. Accident records incur safety premium to construction companies and this leads to cost increase. Hallowell [69] argued that the direct cost effect due to injuries and fatalities in the construction industry is more than billions of dollars annually [69]. Also, the indirect cost effect of these incidents is estimated six times more than the direct costs [70, 71]. Effective safety management also improves productivity and efficiency in project execution [72].

IV. DISCUSSION

As the results from thorough review on the input measures identified in the construction management research, it has been recognized that they have significant influence on project outcomes. Despite their importance, no attempt exists to address them systemically together for performance assessment in previous benchmarking studies. Therefore, the CII's 10-10 Program adopted a multi-perspective assessment approach to evaluate those project inputs systemically [1]. The program quantifies the scores of ten input measures, and each indicator is compared to similar projects [3]. The exclusive capability for project diagnosis is acknowledged by increasing attention on the program from the industry. For two years since the program was initiated in 2013, 480 phase-level data have been collected from 36 owner and 37 contractor companies. The 10-10 database consisted of 372 industrial, 93 building, and 15 infrastructure projects as of the end of 2014.

As data accumulate, initial statistical inference is being carried out to identify the current practice norms of the 10 input measures with regard to industry sector, phase, and project type. In addition, it is expected to reveal the relationships between input measures and outcome measures in the program. Through the results of initial data analyses, the input measures present the management status of each project phase effectively and are proven to have significant influence on project success. In addition, the efforts to link each leading indicator with CII resources (e.g., CII tools and research) are currently in progress [1]. This linkage is expected to soon help projects identify which implementation resources should be considered for improvement based on the benchmarking results.

One limitation of this study is that the input measures are not exclusively independent. That is, some input measures are correlated with each other at some extent because construction-specific measures partially include the attributes of basic management measures. The basic management functions largely influence the implementation of the construction-specific practices. It implies that higher scores on POLC are likely to get higher scores of the construction-specific measures. In this regard, POLC is regarded as superordinate indicators impacting on the remaining six measures.

V. Conclusion

The theoretical background of the ten input measures adopted in the 10-10 Program is presented in this paper. Those input measures have been addressed as critical factors influencing project outcomes in numerous performance studies. While the input measures have been recognized as critical factors influencing on project outcomes, there has been no study quantitatively evaluating how they are operated in the construction industry. The authors strongly believe that the 10-10 Program contributes to revealing the current status of their uses, and thus will be helpful in establishing proactive strategies improving construction project performance.

Current progress of the 10-10 program and the limitation related to inter-relationships between input measures are also discussed. The attempt to link each leading indicator with potential CII resources is being carried out so that projects can easily identify which implementation resources for improvement [1,3]. Moreover, since the number of companies and projects participating in the program increase with time, various analyses regarding project management efforts for project execution and successful project delivery should be conducted as future research.

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