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International Journal of Project Management 35 (2017) 1 – 12

International Journal of Project Management

www.elsevier.com/locate/ijproman

Discovering complexity and emergent properties in project systems: A new approach to understanding project performance

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Received 4 April 2016; received in revised form 30 September 2016; accepted 3 October 2016
Available online 27 October 2016

Abstract

An integrated performance assessment framework based on consideration of complexity and emergent properties in project systems is proposed in this study. The fundamental premise of the proposed Complexity and Emergent Property Congruence (CEPC) framework is that a greater level of congruence between project emergent properties and complexity can potentially increase the possibility of achieving performance goals in construction projects. Two dimensions of project complexity (i.e., detail and dynamic complexity) and three dimensions of project emergent properties (i.e., absorptive, adaptive, and restorative capacities) in the proposed CEPC framework were verified through information collected from in-depth interviews with nineteen senior project managers. In addition, contributing factors to different dimensions of project complexity and emergent properties were identified from the interviews. The results highlight the significance of the CEPC framework in understanding complexity and emergent properties in project systems and providing a new theoretical lens for project performance assessment.

Keywords: Performance assessment; Project systems; Complexity; Contingency theory; Emergent property

1. Introduction

Over the past few decades, different project management theories and methods have been created to improve performance in construction projects. Despite these efforts, construction projects still suffer from low efficiency. A study conducted by the Construction Industry Institute (CII) shows that only 5.4% of the 975 construction projects studied met their planned performance objectives in terms of cost and schedule (Construction Industry Institute, 2012). One of the important obstacles in improving the efficiency of construction projects is that the traditional performance assessment theories are incapable of capturing and dealing with the increasing complexity of modern construction projects (Shenhar, 2001; He et al., 2009). Project performance assessment is a continuous process to understand and predict project performance outcomes based on various variables in projects (Russell et al., 1997). Project practitioners rely on effective and accurate project performance assessment to perform planning and control. Thus, there is a need for a better understanding of behaviors and performance of projects operating in complex environments. To address this knowledge gap, this study focuses on achieving a better understanding of project performance through investigation of a project system's capability to cope with complexity.

To this end, this study adopts theoretical underpinnings from complex systems science and organizational theory in order to propose an integrated framework for performance assessment. In the proposed framework, construction projects are assessed as complex systems. The capability of a project system to cope with complexity is investigated through system-level emergent properties arising from interactions and interdependencies between different project constituents. Performance of a project system is evaluated based on the extent of congruence between the project system's emergent properties pertaining to its capability to cope with complexity and the level of project

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http://dx.doi.org/10.1016/j.ijproman.2016.10.004
0263-7863/00/

complexity. A greater level of congruence between project emergent properties and complexity can potentially increase the possibility of achieving performance goals in construction projects. A qualitative research method was used to verify the proposed framework and further investigate the different dimensions of complexity (i.e., detail and dynamic complexity) and emergent properties (i.e., absorptive, adaptive, and restorative capacities) in the context of construction project systems via semi-structured interviews with senior project managers.

The following sections are arranged as follows. First, the theoretical background of the proposed framework is presented. Second, different components of the proposed framework are introduced and explained. Third, the data collection and analysis processes related to the interviews with senior project managers are demonstrated. Fourth, the data analysis results are presented. Finally, the significance of this research, its potential implications, limitations, and future research efforts are discussed.

2. Background

2.1. Traditional performance assessment approaches

Traditional approaches pertaining to performance assessment in construction projects are rooted in a reductionist perspective (Levitt, 2011; He et al., 2009). From the reductionist perspective, a construction project is simply an assemblage of various processes and activities, which are connected in order to perform the predefined baseline plan. In traditional studies related to performance assessment, the successes and failures of construction projects were often investigated based on the attributes of individual processes, activities, or constituents in projects, such as financial conditions of owners, experience of contractors, project managers' competence, quality of site management and supervision, and availability of materials and equipment (Chan and Kumaraswamy, 1996; Chan et al., 2001; Iyer and Jha, 2005; Alzahrani and Emsley, 2013). The main limitation of this stream of studies is their deterministic and one-size-fits-all nature. The assumption underlying these studies is that certain attributes (so-called critical success factors) guarantee success of a project regardless of the existing level of complexity. However, modern construction projects usually are large-scale systems operating in dynamic environments. Many modern construction projects are complex systems composed of multiple interrelated processes, activities, players, resources, and information (Zhu and Mostafavi, 2014a). Changes in one constituent of a project system can cause unforeseen changes in other constituents. The feedback processes and linkages between different constituents cause the project to evolve over time (Taylor and Ford, 2008). Hence, the behaviors and performance outcomes of construction projects are dynamic and unpredictable due to the complex interdependencies between various constituents in project systems. Traditional performance assessment approaches lack consideration of the impacts of different levels of complexity on project systems, and thus, fail to capture the dynamics and unpredictability of project performance.

In another stream of studies, researchers have investigated different aspects of complexity and their impacts on project performance. Various factors (e.g., project size, uncertainties in scope, technological novelty, diversity of tasks, and frequency of changes) contributing to project complexity were identified and their effects on project performance were studied (Williams, 1999; Bosch-Rekveldt et al., 2011; Giezen, 2012; Kardes et al., 2013). Although this stream of research has emphasized the significance of complexity in assessment of project performance outcomes, it fails to consider ways a project copes with complexity. The majority of the existing studies in this stream of research investigated the level of complexity as an independent influencing factor affecting project performance. However, each project system has unique characteristics in terms of the ability to cope with complexity. The extent of the impacts of complexity on the performance of a project depends greatly on the ability of the project system to cope with complexity. Hence, outcomes of this stream of research may explain why a project fails due to complexity. But these studies do not provide insights regarding how to proactively design project systems that are capable of successfully operating in complex contexts.

2.2. Performance assessment based on contingency theory

The literature on contingency theory, as another avenue of research, provides a new perspective for understanding and assessing the performance of projects. The fundamental premise of contingency theory is that organizational effectiveness results from fitting organizational characteristics, such as its structure, to contingencies that reflect the situation of the organization (Donaldson, 2001). Existing literature has already identified contingency theory as a promising approach for understanding, designing, and managing projects (Levitt et al., 1999; Shenhar, 2001; Hanisch and Wald, 2014). In contrast to the "one-size-fits-all" approach, contingency theory helps to better plan and manage projects of different kinds in varying conditions.

In a complex construction project system, the level of complexity can be viewed as a contingency factor. Hence, the efficiency of a project is contingent on the congruence between the project system's capability to cope with complexity (i.e., project characteristics) and the level of complexity (i.e., contingency factor). As shown in Fig. 1, there are four possible conditions, based on the level of congruence that pertains to complexity in a project system. In conditions A and C, a project system's capability to cope with complexity is congruent with its level of complexity. Hence, both conditions have greater likelihoods of achieving project performance goals. On the contrary, an incongruent relationship between a project system's capability to cope with complexity and the existing level of complexity may lead to undesirable outcomes in a project. For example, in condition B, a project system's capability is insufficient to cope with the existing level of complexity, and thus the project may have a lower chance of achieving performance goals. In condition D, a project system has a higher level of capability to cope with complexity than actually required, and thus it might not be cost-effective.