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Exploring performance of the integrated project delivery process on complex building projects

Harrison A. Mesa [a,b,*], Keith R. Molenaar [a,1], Luis F. Alarcón [b,2]

[a] Department of Civil, Environmental and Architectural Engineering, University of Colorado Boulder, Boulder, CO, USA
[b] Department of Construction Engineering and Management, Pontificia Universidad Católica de Chile, Santiago, Chile

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Abstract

Many building projects do not meet owners' performance expectations. Integrated project delivery (IPD) has emerged as a new delivery system with the potential to provide better performance through more supply chain integration. However, there is a knowledge gap surrounding how project delivery systems, IPD in particular, affect supply chain relationships and potential project performance. To fill this gap, we applied a simulation method, General Performance Model (GPM), to assess the interactions between numerous project delivery variables and compare potential performance between delivery systems. This study presents a GPM analysis of a complex hospital project and based upon cross-impact assessments by owners, architects, constructors, and specialty contractors from the building industry. The results found the most influential drivers of project delivery performance to be communication, alignment of interest and objectives, team working, trust, and gain/pain sharing. The performance of the supply chain was found to drive the project delivery performance.

Keywords: Project delivery; Integrated project delivery; Supply chain relationships

1. Introduction

The design and construction industry is changing in its approach to the integration of construction teams in the design process. Vertical building construction currently uses three primary project delivery systems: design–bid–build (DBB), construction management at risk (CMR), and design–build (DB). Owners choose these delivery systems, in part, to meet their goals for time, cost, and quality performance. Despite this range of options, many building projects do not meet the owner's performance expectations (Lichtig, 2006). Researchers often cite the lack of integration in these delivery systems as the reason for this poor performance. Authors suggest that the building design and construction industry needs to move towards a better coordination of participants and more collaborative approaches to overcome these problems (Egan, 1998; Latham, 1994; Mitropoulos and Tatum, 2000; Kim and Dossick, 2011). In recent years, the United States (U.S.) construction industry has started to use integrated project delivery (IPD) in attempt to achieve more collaboration and, hopefully, better performance.

The relevant literature analyzes the impact of the three primary U.S. project delivery systems on cost, time, and quality (Konchar and Sanvido, 1998; Hale et al., 2009; Thomas et al., 2002; Ibbs et al., 2003). While the IPD system proposes to be a response to poor performance in the design and construction industry, there is a knowledge gap surrounding how project delivery systems, IPD in particular, affect the project environment, supply chain relationships and potential project

* Corresponding author at: Av. Vicuña Mackenna 4860, Macul, Santiago, Chile.
E-mail addresses: hmesa@uc.cl (H.A. Mesa), keith.molenaar@colorado.edu (K.R. Molenaar), lalarcon@ing.puc.cl (L.F. Alarcón).
[1] Professor address: Box 428, Boulder CO 80309–0428.
[2] Professor address: Av. Vicuña Mackenna 4860 – Macul, Santiago, Chile.

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performance. Due to the number of required variables to analyze and the limited number of completed IPD projects, an empirical study of project performance is impractical. This research helps to fill the gap of knowledge by modeling IPD performance through a methodology of decision making and simulation called the General Performance Model (GPM) (Alarcón and Ashley, 1996, 1998). The GPM conceptual model was applied to a complex hospital project and cross-impact assessments were made by owners, architects, constructors, and specialty contractors from the building industry. While this paper presents an analysis of only one project application, the model can be applied more widely. The GPM analysis approach provides insights into how project delivery systems impact project performance at the supply chain level. The GPM model structure provides a contribution that researchers can use to explore project delivery performance with a multitude of project delivery, contracting, and procurement options.

This study addresses the following research question: How do the organizational strategy, contractual relationship, and supply chain relationships affect project delivery performance? In other words, we want to explore what factors drive project delivery performance and how the project delivery system creates an environment for people and processes to be successful. This research will add to the body of knowledge and delivery system research and help owners to choose appropriate systems for their projects.

The paper is organized in six sections. In the first section, we explain our research methodology. We then explain the GPM conceptual model and define main concepts such as the project delivery system and the supply chain. In the third section, we explain the data collection and the procedure for our consensus-building workshop. Next, we explain the GPM mathematical model assessment. In the fifth section, we present the analysis of simulation results along with the model sensitivity analysis and a discussion of project delivery performance. We conclude with a summary of the contributions to the body of knowledge, discuss the study limitations, and make suggestions for future research.

2. Methodology

Few studies have explored how the project delivery system is related to the project environment, supply chain relationships and potential project performance. The most often cited studies on project delivery system performance have applied statistical analyses of data from completed DBB, DB, and CMR projects to show which delivery system enables better project performance. The most common metrics relate to cost, time, and quality (Konchar and Sanvido, 1998; Hale et al., 2009; Thomas et al., 2002; Ibbs et al., 2003). However, a statistical study of IPD projects is impractical due to the low number of completed projects (El Asmar et al., 2013). Statistical methods also provide a limited understanding of the relationships between the project delivery factors that we wish to explore. Simulation modeling provides an alternative approach to exploring project delivery performance. Simulation modeling can take advantage of professional experience where aggregate project data are not available. It can also provide a richer understanding of the variables that drive performance.

Due to the nature of this research and the number of variables that require consideration, we chose cross-impact analysis (CIA) as an appropriate methodology of analysis. CIA allows for capturing uncertainty propagation and the interaction among variables inherent in a decision-making process (Tran et al., 2015). Researches have applied CIA in different areas in the construction industry. Calhoun and Hallowell (2010) conducted a pairwise cross-impact analysis to quantify the interaction among safety program elements. Tran et al. (2015) developed a hybrid CIA approach to project delivery decisions in highway design and construction. However, no previous study attempted to explore the relationship between project performance, delivery systems, and supply chain relationships through CIA.

In this research, we use an advanced form of CIA that was developed for strategic decisions in the design and construction industry, called General Performance Model (GPM) (Alarcón and Ashley, 1992, 1996). The GPM approach has been implemented in different areas in the construction industry. Venegas and Alarcón (1997) developed a model for the selection of long-term strategic planning approaches for construction firms. Alarcón and Mourgues (2002) developed a model for the selection of a contractor based on a set of performance criteria. Given the lack of project data for IPD projects, but the wealth of practitioner knowledge about project delivery processes, the GPM method is appropriate to measure potential IPD project performance in comparison to other available delivery systems. Additionally, the GPM approach has the ability to evaluate the simultaneous effect of multiple strategies and provide a sensitivity analysis of project outcomes on various factors (Alarcón and Ashley, 1996, 1998). Given the fact that these type of analysis is essential to answer the research questions, the GPM method is appropriate for this study.

The GPM methodology consists of conceptual and mathematical model structures. The conceptual model is a simplified model of the variables and interactions that influence project performance. The mathematical model uses cross-impact analysis and probabilistic inference to capture the uncertainties and interactions between project variables. A generic GPM conceptual model has the following variables: strategies, drivers, process, outcomes, and project agents (Alarcón and Ashley, 1996, 1998; Venegas and Alarcón, 1997).

According to the GPM variables and their logical sequence of impact, the authors defined a conceptual framework that describes the building project delivery process (Fig. 1). A literature review on project delivery systems and supply chain relationships identified and defined the key variables for inclusion in the GPM conceptual model. Upon completing the GPM model, the authors conducted a validation and assessment process through a series of workshops. At these workshops, a group of experienced professionals with different roles in the building construction industry (i.e., owner, contractor, subcontractor, and designer as explained later) assessed the impact among the variables. This assessment comprised the evaluation