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Perceiving interactions and dynamics of safety leadership in construction projects

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ABSTRACT

This paper develops a Structural Equation Model (SEM) based approach to identify roles of leadership in managing construction safety performance in a changing project environment. A model consisting of 5 latent variables and 26 observed variables is established to reveal relationships between different stakeholders' leaderships and construction safety performance according to a survey of 464 valid respondents. The built model is verified through several tests, including common method bias test, hypothesis test, multiple group invariance test, and goodness-of-fit tests. Impacts of path coefficient, stakeholder participation, and construction process dynamics on construction safety performance are investigated and analyzed in detail. Results indicate that: (i) At the pre-construction phase, the owner party has a strongest total effect on managing construction safety performance; (ii) At the construction phase, the contractor party plays a dominant role in managing construction safety performance associated with a highest value in both total and direct effects; and (iii) The role of the indirect effect that participating stakeholders play on construction safety performance becomes weakened as the project gradually steps from pre-construction into construction phase. The novelty of the developed approach lies in its capabilities in (a) perceiving causal relationships among stakeholders from survey data, (b) identifying leading roles on managing construction safety performance, and (c) revealing the transfer of duty and responsibility within different stakeholders as the construction advances. The research findings can assist to allocate the duty on construction safety management among different stakeholders and further facilitate the enhancement of safety performance in the construction industry.

1. Introduction

Construction is one of the most dangerous industries worldwide (Waehrer et al., 2007; Sacks et al., 2009), leading to a common interest in improving construction safety performance due to humanitarian reasons and rising costs of worker compensation and Occupational Safety and Health Administration (OSHA) fines (Jaselskis et al., 1996). Statistics from USA, UK, and Hong Kong reveal no significant reduction in the number of fatalities in the construction industry (Zhang and Fang, 2013). In the Chinese construction market, the number of construction accidents and the fatalities remain stubbornly high (Wu et al., 2015b; Zhang et al., 2017). Numerous researchers suggested the continuous unsafe conditions were mainly because of a misalignment of management commitment and stakeholders' actions, that is, lack of safety leadership (Tam et al., 2004; Martin and Lewis, 2013). Effective leadership plays an important role in ensuring the success of temporary construction onsite organizations that are facing a high degree of uncertainty (Tyssen et al., 2014). Strong safety leadership should be the key to enhancing the construction safety performance, particularly for the countries where construction industries are facing significant safety challenges (Roundtable, 2012; Wu et al., 2015c).

Leadership is defined as "a process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task" (Chemers, 1997). Safety leadership has emerged within the Occupational Health and Safety (OHS) literature as a key construct in construction safety management. Wong et al. (2017) concluded that workplace supervisors had a substantial influence on the safety performance of their employees. Much of the research has considered

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safety leadership as an antecedent to lagging indicators. Traditional safety control in the construction industry is typically based on lagging indicators (e.g. Total Recordable Incident Rate (TRIR) and Experience Modification Rate (EMR) on worker's compensation) (Hinze et al., 2013; Nassar and AbouRizk, 2014). However, these indicators have often been criticized with little predictive value to system improvement (Carder and Ragan, 2003; Cooper and Phillips, 2004). Grabowski et al. (2007) noted that a growing number of safety professionals questioned the value of lagging indicators and argued that lagging indicators did not provide enough information or insight to effectively avoid future accidents. Mengolini and Debarberis (2008) stated that an unbalanced focus on lagging after-the-fact based measures may convey an unintended message that safety prevention was less important. Choudhry (2014) indicated traditional indicators focused on the afterward analysis but paid less attention to internal factors. In general, the criticism of incident-based indicators coincided with the growing attention on exploring leading factors and cause-effect relationships between internal factors and construction safety performance. Sinelnikov et al. (2015) demonstrated that safety leadership potentially enables leading indicators of OHS, and indicated that it would be easier to take preventive action through leading indicators when leading indicators received more attention in management coordination and collaboration.

Many industrial participants/stakeholders are involved in safety issues in construction, and effective collaboration of those stakeholders can contribute to ensuring construction safety performance. The organizational commitment to safety within each stakeholder has a significant impact on cultivating a positive OHS culture (Ng and Tang, 2001). Chan et al. (2004) indicated that the most influential factor driving safety performance in the construction industry was the organizational safety policy and behaviors. Erickson (2000) stated that improvements in organizational structure, safety responsibility and accountability, communication, employee involvement, and employee responses and behavior could help improve construction safety performance. Wong et al. (1999) noted that safety system (safety committees and departments), written safety policies, measurable safety targets, and communication of safety policies to various concerned parties should be essential to construction safety. According to Tam and Fung IV (1998), safety awards or incentive schemes, safety training schemes, safety committees and level of subcontracting should be recommended for consideration of the improvement of construction safety performance. Overall, many factors that exert significant impacts on construction safety performance have been identified by different scholars. However, causal links between those internal factors and external unwanted outcomes have not been properly addressed (Chinda and Mohamed, 2007). The relationship between those safety-related internal and external factors within different stakeholders in construction projects has not been fully validated. The main reason is that conclusions rely largely on cross-sectional studies, where empirical links or correlations, rather than causal relations, are obtained between variables. Longitudinal studies of safety leadership, however, are few, where causalities should be validated with time-series data and panel data (Wooldridge, 2010).

A long debate on the allocation of duty and responsibility for construction safety management always exists among main stakeholders. Gambatese (2000) indicated that owners held a proactive role in safety and can significantly influence the safety experience on a construction project. Huang and Hinze (2006) noted that the owner's involvement was especially important when the construction firm was not fully committed to safety. Wu et al. (2015a) concluded that the owner's greatest leverage was the leadership to influence safety perception, motivation, and behavior of other stakeholders. Hadidi and Khater (2015) emphasized the significance in selecting contractors at the bidding stage to assure loss prevention and better safety orientation during project implementation. Kapp et al. (2003) recognized that the competitive bidding process forced contractors to cut safety and quality budget items in order to win the job, which would exert great negative impacts on construction safety management. Conchie et al. (2013), on the other hand, supported the importance of supervisors' safety leadership in promoting construction safety. Behm (2005) highlighted the importance of the role of the designer in construction safety and suggested linking construction fatalities to the design for construction safety concept, after a review of 224 fatality investigation reports. In general, a common agreement on which party should play a leading role of leadership in construction safety has not yet been reached. This research intends to propose a Structural Equation Model (SEM) based approach to address these deficiencies, aiming to reveal causal relationships and interactions among different industry stakeholders as to perceive their safety leadership and improve construction safety performance.

In recent years, two statistical approaches, including SEM and exploratory factor analysis (EFA), have been proposed to empirically reveal and test inter-relationships in the hypothetical model (Zhang et al., 2016). EFA is capable of identifying the structure among the questionnaire items, where no prior knowledge of factors or patterns of measured variables exists (Fabrigar and Wegener, 2011). Compared with EFA, SEM is not only able to perceive complex structural relationships among variables, but also estimate all coefficients in the model simultaneously (Xiong et al., 2015). Actually, SEM is a statistical methodology that takes a confirmatory approach to the analysis of a structural theory. It represents causal processes that generate observations on multiple variables, which can handle complex relationships among variables, where some variables can be hypothetical or unobserved (latent variables). SEM is able to estimate all coefficients in the model simultaneously, and thus, one is able to assess the significance and strength of a particular relationship in the context of the complete model. In addition, the hypothesized model can be tested statistically in a simultaneous analysis of the entire system of variables to determine the extent to which it is consistent with the data (Dion, 2008; Martínez et al., 2010). Several research studies have reported the successful use of SEM. For instance, Martínez-Córcoles et al. (2011) used SEM to analyze the interaction between leadership and employees' perceived safety behaviors and indicated that the leader behavior generated a higher safety climate among members. Hsu et al. (2012) conducted a study on the application of SEM in systematic safety performance model fitness verifications and revealed that the safety performance can be composed of four different dimensions. Al-Refaie (2013) examined effects of organizational safety management and workgroup level factors on safety self-efficacy, safety awareness, and safety behavior in Jordanian companies using SEM. Wu et al. (2015c) proposed a systematic SEM-based approach to the evaluation of prospective safety performance on construction sites, with causal relationships and interactions between enablers and goals taken into account. Generally, SEM has proven to be an effective tool in testing and investigating inter-relationships among hypothesized models. However, this kind of the inter-relationships is static at a specific time point, leading to an unknown situation when certain parameters or constraints are changed over time. So far, no SEM models have ever investigated structural dynamics during the model evolution over time.

The main objective is to answer the following questions: (i) How to perceive interactions among multiple stakeholders during the construction safety management practices? and (ii) Who plays a leading role in safety leadership in a changing project environment? In this research, an SEM-based causal model for revealing relationships between behaviors of different stakeholders and construction safety performance is hypothesized and tested using data gathered via a questionnaire survey. Impacts of path coefficients on construction safety performance are explored to gain insight on inter-dependence for stakeholder participation in safety leadership. The evolutionary dynamics of safety leadership as construction process progresses are investigated by comparing the fitted SEM at different construction phases (e.g., preconstruction and construction phases). This research attempts to provide a dynamic perspective to perceive the updating interactions among