Safety Science 59 (2013) 28–45

Contents lists available at SciVerse ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Effect of safety investments on safety performance of building projects

Yingbin Feng *

University of Western Sydney, Locked Bag 1797, Penrith, NSW, Australia

ARTICLE INFO

Article history:
Received 20 August 2012
Received in revised form 2 April 2013
Accepted 11 April 2013
Available online 16 May 2013

Keywords:
Construction
Safety
Safety investments
Safety culture
Project hazard
Risk compensation

ABSTRACT

The construction industry is increasingly reliant on the voluntary effort of contractors to reduce accidents on construction sites. This study aims to investigate the effects of contractors' safety investments on safety performance and identify the factors influencing the effects of safety investments on safety performance. To fulfill the research aims, a regression/correlation research design was adopted. Data were collected using multiple techniques (structured interviews, archival data and questionnaires) with 47 completed building projects. Bivariate correlation and moderated regression techniques were used to analyze the data collected. The results show that the effect of basic safety investments on safety performance does not hold constant under different project conditions. Basic safety investments have a stronger positive effect on accident prevention under a higher safety culture level and a project hazard level; while the effect of basic safety investments on accident prevention might not be positive if the project hazard level and safety culture level of the project were low. The implication of the findings is that more protection and safer environment do not always produce better safety performance without the improvement of safety culture. To achieve better safety performance, contractors need to implement the interventions that synthesize physical protection with cultivation of positive safety culture. The findings of this study offer a better understanding of the theory behind the role of safety investments in accident prevention and provide the theoretical basis to support contractors' decisions to invest in safety.

1. Introduction

In Singapore, the government undertook a fundamental reform in the Workplace Safety and Health (WSH) framework in 2005 in order to achieve a quantum improvement in the safety and health for workers. The new framework is guided by three principles: (1) to reduce risk at source by requiring all stakeholders to eliminate or minimize the risks they created; (2) to promote greater industry ownership of WSH outcomes; and (3) to prevent accidents through higher penalties for poor safety. It was designed to engender a paradigm shift in mindset where the focus is on reducing the risks and not just complying with the prescriptive rules (Singapore Ministry of Manpower, 2007). Industry is required to take greater ownership of safety outcomes. Businesses should realize that good WSH performance will enhance business competitiveness, e.g. good corporate image, cost savings in terms of higher productivity and fewer disruptions to work due to accidents. The potential benefits of good safety performance may motivate businesses to voluntarily invest in accident prevention activities, instead of just complying with the rules and regulations.

Many modern managers treat preventing accidents as an investment – an investment with significant returns, both humane and economic (Bird and Germain, 1996). Brody et al. (1990) pointed out that when prevention activities are perceived as sufficiently profitable, the investor will likely undertake the investments voluntarily. However, it is still debatable whether an increase in safety investments can result in the improvement of safety performance (Teo and Feng, 2010). Although a popular assumption holds that higher safety investment results in better safety performance (Levitt, 1975; Laufer, 1987; Brody et al., 1990; Hinze, 2000), little empirical evidence supports this assumption. Crites (1995) compared safety performance with the size and funding of formal safety programs over an 11-year period (1980–1990). However, it was found that safety performance was independent of – or even inversely related to – safety investments. Tang et al. (1997) examined the function of the relationship between safety investments and safety performance of building projects in Hong Kong and found a weak correlation coefficient (0.25) between safety investments and safety performance. They assumed that the low coefficient of correlation (0.25) might be due to the difference in safety culture of the different companies. However, no empirical evidence was provided to support this assumption. Although Crites (1995) and Tang et al. (1997) provided empirical evidence for the relationship between safety investments and safety performance, they did not identify the factors influencing this relationship. The reason why safety performance is weakly or even inversely related to safety investments remains unclear.

Against this background, this study aims to investigate the effects of safety investments on safety performance in the construction environment. The specific objectives are: (1) to examine the effects

* Tel.: +61 2 4736 0468; fax: +61 2 4736 0833.
E-mail address: y.feng@uws.edu.au

0925-7535/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ssci.2013.04.004

of safety investments on safety performance; and (2) to identify the factors influencing the effects of safety investments on safety performance. The research objectives of this study suggest a project level of analysis. The unit of analysis in this study is a contractor's project. Since safety costs vary with regions and industries, this study was conducted in the context of building construction in Singapore. This is because (1) building construction is the most significant sector in Singapore's construction industry as the demand for buildings is around 70% of the total construction demand (Building and Construction Authority, 2011) and (2) time constraints impede the development of a universal model to cater for all types of construction projects.

The next section considers the theoretical basis of this study. The factors influencing safety performance of construction projects are discussed and the research hypotheses are developed based on the literature review.

2. Factors influencing construction safety performance

The research in accident causation theory was pioneered by Heinrich (1931), who analyzed 75,000 accidents reports and developed the domino theory (model) of accident causation. Heinrich's (1931) analysis led him to conclude that 88% of accidents were caused by unsafe acts; while only 10% of accidents were caused by unsafe conditions. Heinrich's (1931) theory was criticized for focusing too much on the immediate causes of accidents. Many researchers have updated Heinrich's (1931) domino model with an emphasis on management as a primary cause in accidents, e.g. the updated domino sequence (Bird, 1974; Bird and Loftus, 1976), Adams (1976) updated sequence and Weaver's (1971) updated dominoes. The multiple causation models, which are management-based instead of domino based, hold that many contributing factors, causes and sub-causes combine together in a random manner causing an accident (Petersen, 1971). Hopkins (1995) suggested that it is misguided to attribute accidents to either unsafe acts or unsafe conditions because most accidents are the result of a complex interaction of multiple causes. In the construction industry, Abdelhamid and Everett (2000) grouped the root causes of accidents on construction sites into four categories: management failure; unsafe acts of workers; non-human-related events; and an unsafe working condition that is a natural part of the initial construction site conditions. Fang et al. (2004) categorized on-site hazards into immediate hazard factors and contributing hazard factors. An immediate hazard factor is a factor that can cause an accident physically and directly, whether the accident happens or not, including unsafe acts (e.g. horseplay when using a power tool, not wearing personal protective equipment at all times, and not following safe operating procedures) and unsafe conditions (e.g. open-sided floors, defective ladders, improperly constructed scaffolds, defective tools/equipment, uneven terrain, and concealed ditches). A contributing hazard factor is a factor that can further explain the immediate hazard factor, including safety management policy (e.g. hazard analysis or risk assessment, safety inspections, and safety incentives), managers and workers' mental or physical conditions (e.g. safety perceptions/attitudes of managers and workers and workers' health conditions), and initial construction site conditions (e.g. the design and volume of temporary structures involved in the project and the volume of welding and cutting works on site).

Efforts to prevent accidents are likely to be shaped by the root causes of accidents (Lingard and Rowlinson, 2005). The accident causation theories suggest that lack of management control is the root cause of accidents and thus the accidents could be somewhat prevented through management efforts. The *Oxford English Dictionary* (OED, 2012) defines control as the ability or power to determine or influence people's behaviour or the course of events. However, due to people's strong desire to completely master their environment and control chance events (Adler, 1930; Hendrick, 1943) and the fact that skill and chance factors are so closely associated in people's experience, Langer (1975) found that there is an expectancy of a personal success probability inappropriately higher than the objective probability would warrant, which is referred to as the illusion of control. Langer's (1975) research suggests that the lack of management control cannot account for all the failures in managing WSH risks due to the role of chance factors. Therefore, in addition to the level of management efforts in accidents prevention, safety performance of building projects is also associated with the inherent project hazards and non-human related events, such as natural disasters and inclement weather (Abdelhamid and Everett, 2000; Imriyas et al., 2007; Teo and Feng, 2010, 2011). The management efforts could be in the form of physical input, such as the investments in safety personnel, safety facilities and equipment, safety training, and other safety related activities, and cultural input, such as the cultivation of safety culture on construction sites (Teo and Feng, 2011). The inherent project hazard is a natural part of the initial construction site conditions owing to the scope and location of the project (Abdelhamid and Everett, 2000; Imriyas et al., 2007). Non-human related events like natural disasters and inclement weather are beyond control and prediction (Teo and Feng, 2010), and thus they were not within the scope of this study.

Previous studies have examined the individual impacts of safety investments (e.g. Brody et al., 1990; Hinze, 2000; Tang et al., 1997), safety culture (e.g. Cooper, 2000; Choudhry et al., 2007; Guldenmund, 2000) and project hazard level (e.g. Davis and Tomasin, 1996; Imriyas et al., 2007; Jannadi and Assaf, 1998) on safety performance. However, no study appears to have been conducted to investigate the combined effects of the three factors namely safety investments, safety culture and project hazard. It is possible that safety performance of building projects is the result of the interactions of safety investments, safety culture and initial project hazard. The effect of any factor on safety performance may vary with the changes in the other two factors. Thus, the following two hypotheses are set out.

Hypothesis 1. The effect of safety investments on safety performance varies with the project hazard level.

Hypothesis 2. The effect of safety investments on safety performance varies with the level of safety culture.

3. Methods

3.1. Design

The objectives and hypotheses of this study indicate that this is a correlational research study, which seeks to discover or establish the existence of a relationship/association/interdependence between two or more aspects of a situation (Fellows and Liu, 2008; Kumar, 2005). According to Tharenou et al. (2007), the research which aims to test the relationships between variables is suitable for the use of the correlation or regression research design. Therefore, a regression/correlation research design was adopted by this study. The unit of analysis in this study was defined as a contractor's project. Safety investments are confined to those incurred by building contractors (including prime contractors and subcontractors). In order to collect primary data, multiple data collection techniques (structured interviews, questionnaires, and archival records) were used in this study.

3.2. Measures

Based on the hypotheses, four research variables are identified: safety investments, safety culture, project hazard level, and safety