



# Occupational risks, accidents on sites and economic performance of construction firms



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## ABSTRACT

This paper examines the relationships among site risk, accident rate and firm economic performance in construction industry. We first assess safety levels on site using a specific tool we have developed, CONSRAT. We have examined during 6 years (2004–2009) 502 construction sites of 272 Spanish companies in Mallorca. We built a panel data with these safety assessments, the firm financial performance and the accident rates.

Our general hypotheses are that risk on site has an effect on accident rates and the accident rates affects firm economic performance. On one hand, we obtain a significant positive linear relationship between site risk and accident rate. On the other hand, we find a significant quadratic relationship (inverted U shape) between accident rate and economic firm performance. Our empirical evidences suggest a complex relationship between those variables. Specifically, for a low range of accidents we can observe that company profitability increases while accident rate grows up, arriving to a tipping point from which more additional accidents will reduce the company profitability.

These results suggest that we need policies to control accident rates, since the total cost of accidents by itself might not be enough to influence firms to invest in safety prevention.

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## 1. Introduction

There is an enormous amount of academic work studying which construction site conditions are prevalent when the accident occurs. This literature is reactive in nature as it is aimed to explain probable risk conditions on sites involving accident event reports (Camino López et al., 2011a; Cheng et al., 2012; Cheng et al., 2010a,b; Conte et al., 2011; Hinze and Teizer, 2011; Liao and Perng, 2008; López Arquillos et al., 2012; McVittie et al., 1997; Nishikitani and Yano, 2008). Another important research line proposes methods to conduct in depth analysis of occupational accidents, although only large companies seem to be using these methods (Jørgensen, 2016). Among them we have the “Story-builder” (Bellamy et al., 2007) in the framework of Worm project, where over 20.000 serious accidents were analysed, jointly with their barriers, and 64 types of hazards were summarised (Ale, 2006; Bellamy, 2010). In the specific context of Spain, where the present study has been carried out, there is a vast research on accident analysis based on different factors. Most of these studies anal-

yse the information contained in the accident reports which are structured following the ESAW (European Statistics on Accidents at Work) reporting system (European Commission, 2002). A number of recent published studies analyse accidents rates and their severity in several different sectors of activity. For example Suárez-Cebador et al. (2015) analyse accidents at the Public University, Sanmiquel et al. (2015) in the mining sector, or Carrillo-Castrillo et al. (2016) at Andalusian manufacturing sector. Also, we can find several studies in the construction sector trying to describe and analyse accidents severity and fatality based on several general factors (Camino López et al., 2011b, 2008; Pérez-Alonso et al., 2011). Other more specific studies have connected accident rates with the type of construction processes (Rubio-Romero et al., 2014) or with specific worker characteristics (López-Arquillos et al., 2015).

Other line of research within health and safety (H&S) has adopted a more preventive approach as it tries to avoid accidents through risk assessment based mainly on site conditions (Memarian and Mitropoulos, 2013; Cambraia et al., 2010; Wu et al., 2010; Yang et al., 2012). However, there is a limited number of studies trying to model the relationship between risk conditions on site and the likelihood of accidents. One example is the study by

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Hinze et al. (2013) where the authors analysed which leading indicators can be utilized to assess safety performance (e.g. works, supervisors, managers, owners, and designers, all them at jobsite). Another example, Sparer and Dennerlein (2013) developed a software to identify sites with high accident risks using leading indicators to measure work conditions that can affect the risks. Some studies in the context of Spain have utilized the prediction of accidents and their severity to assess the effectiveness of preventive actions undertaken by private and public entities (Carnero and Pedregal, 2010, 2013). In the specific context of construction, we can also find some studies focused on identifying the most likely causes of accidents for developing predictive models (López Arquillos et al., 2012; Rivas et al., 2011). As we have mentioned before, most of the recent Spanish literature regarding accident analysis has been framed under the well-structured and complete ESAW approach. Despite the clear value and efforts from ESAW methodology to harmonize work accident data gathering, some authors have pointed out that deficiencies on the process of filling the accident forms and reports may limit the accident analysis studies done based on this information (Salguero-Caparros et al., 2015). Specifically, Molinero-Ruiz et al. (2015) have found low to moderate reliability in the coding of those variables related with the accident causes when the accidents forms are filled.

More attention to construction tasks is necessary as studies at task level only represent the 2.28% of all research on H&S in the construction industry (Zhou et al., 2015). There is a lack of field risk exposition measurements on sites (Swuste et al., 2012) because most of the research tend to be epidemiological and mainly focused on accidents.

On another level, H&S has been identified as one of the issues that are relevant for company results, competitive advantage and management performance (Teo and Ling, 2006; Argilés-Bosch et al., 2014; Rechenthin, 2004). Most of the research connecting these issues in construction industry has been theoretical. Following Chalos (1992) theoretical framework of cost of safety (COS model), many scholars have analysed, two well-known dimensions of H&S cost, prevention and accidents costs (Cheng et al., 2010a,b; Feng et al., 2015; Gurcanli et al., 2015; Harshbarger, 2001; HSE, 2015; Ibarrondo-Dávila et al., 2015; Labelle, 2000). Despite the cost of H&S has been studied in some depth, it is surprising the absence of empirical works trying to understand which is the relationship between those costs and the economic benefit of the firms. The cost of occupational accidents is increasing, and therefore raising safety levels would generate a win-win solution for all parts, including the employees, the firm as well as society (EUROSTAT, 2004; Gavius et al., 2009; Jørgensen, 2016). Despite this reasonable relationship, to the best of our knowledge, there is just a one single published paper dealing with this issue (Argilés-Bosch et al., 2014). Particularly, these authors found a linear negative relationship between accident rates and firm financial performance one year ahead. Although, this is a very interesting result it may fail to explain a potential more complex relationship between those variables. Our research question is directed to this point: Is it possible a non-linear relationship between benefits and accidents. Can firms support accident costs without affecting their financial performance? As we will see, our empirical research provides evidences regarding the relationships between risk-accidents on the one hand and between accidents-firm performance on the other hand.

The structure of this manuscript is as follow: (1) A review of the literature and the statement of our hypotheses; (2) A description of the empirical methodology (sample, data collection and empirical design); (3) A report of the results; (4) A discussion of most relevant findings along with some conclusions; (5) A set of limitations of our study and some lines for future research.

## 2. Literature review and hypotheses statement

There is an extensive body of theoretical models connecting risk with accidents. The traditional “bowtie metaphor” from Visser (1998) can be considered as the one of the first theoretical model of the process of H&S management and the consequences of risks. Following this metaphor, existing uncontrollable hazards converge in the so called “central event” which in turn may evolve and diverge into different risks causing potential damages or accidents. The first role of management in such a scenarios is to interpose some barriers to prevent the conversion of hazards into risks, and the second is to build some protections to prevent risks becoming accidents. Fig. 1 shows a reinterpretation of the model by Hollnagel (2008) analysing the two dimensions of risk management (i.e. prevention and protection).

According to Hollnagel's (2008) model, once we have the safe system operating, one of its important consequences is the decreasing of accident rates or, in the best possible situation, that “nothing unwanted happens”.

The problematic issue here is that, despite the proposals of these models, the relationship risk-accident is not always contingent because not all risk expositions finally end in accidents and, alternatively, some good safety systems can have some accident. In fact, most of the risk-exposition does not end in accident, or in other words, we do not have as many accidents as it might be expected probably because workers are able to control most of risk situations (Sundström-Frisk, 1985). As Khanzode et al. (2012) concluded, there is a gap in the literature because the study of risk assessment is disconnected of the causality model of accidents that have been proposed. Although this gap is important at the theoretical level, it is more salient at the level of empirical and field research. There is a clear scarcity of exposition measures on site, and there is also a need to identify which main events are related with accidents (Swuste et al., 2012). Only a limited number of empirical researches connect risk conditions on site with accidents results. Most of these studies are contextualised in the assessment of the effectiveness of specific and very focused safety campaigns (Hale et al., 2010; Kines et al., 2010; Laitinen and Päivärinta, 2010; Laitinen and Ruohomäki, 1996; Spangenberg et al., 2002) or in the assessment of the effectiveness of implemented management systems (Yoon et al., 2013). We have only found one study that considers the level of hazard of a project as a moderator variable over the relationship between accidents rates and the total cost of accidents (Feng et al., 2015). From the literature it can be concluded that there is a need to generate more knowledge about the empirical interaction between risk conditions and accidents. Consequently, the first hypothesis is aimed to test whether or not an increasing relationship exists between risk levels and accident rates when you consider a relatively long span of years:

**H1.** High levels of risk on sites have a positive effect on accidents rates.

Managers seem to ignore the economic consequences of unsafe practices in the workplace (Harshbarger, 2001). Since they don't have accurate estimates of the economic impact of accidents, they cannot consequently assess which is the economic contribution of the function H&S management, and consequently, there seem to be low awareness of its strategic value (Labelle, 2000). In order to keep companies being competitive, many contractors try to control short term total operation costs by executing only basic safety measures during construction project implementation (Cheng et al., 2010a). It is important to prioritise safety, but other demands as finance, client, production and deadlines change these priorities (Jørgensen, 2016). Due to the uncertainty of overall H&S costs and

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