Safety Science 79 (2015) 116–125

Contents lists available at ScienceDirect

Safety Science

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

Managerial accounting for safety management. The case of a Spanish construction company

M.P. Ibarrondo-Dávila [a,*], M. López-Alonso [b], M.C. Rubio-Gámez [b]

[a] Department of Accounting and Finance, University of Granada, Spain
[b] Department of Construction Engineering and Engineering Projects, University of Granada, Spain

ARTICLE INFO

Article history:
Received 24 December 2014
Received in revised form 16 March 2015
Accepted 27 May 2015
Available online 17 June 2015

Keywords:
Accidents prevention
Construction companies
Management accounting
Safety costs
Safety management

ABSTRACT

Managerial accounting can play an important role in supporting safety management in enterprises, by systematically providing appropriate reports to support the decision-making process in the area of risk prevention, benefiting both internal and external stakeholders.

In this paper, we first examine the weaknesses of current managerial accounting systems as regards the provision of systematic information on the cost of measures to ensure health and safety in the workplace. We then propose a model of management accounting to calculate, analyse and control these costs, with particular reference to construction companies. Finally, we implement a case study in a Spanish construction company, focusing on two construction projects carried out in 2008 in Andalusia (Spain). This study reveals that health and safety costs are substantial and remain invisible to the company to a very large degree (more than 90%), because the items that make up this cost are dispersed within other accounting entries, thus remaining unidentified on the income statement. Accordingly, construction companies need to implement a management accounting system to get appropriate information about safety costs, to guide their decisions in safety management.

1. Introduction

Rates of work-related injuries in the construction sector are much higher than in many other areas, as has been documented in various studies and reports (Agilés-Bosch et al., 2014; Chi and Han, 2013; Fung et al., 2010; Manu et al., 2013; Martinez Aires et al., 2010; Montero et al., 2009) and so companies in this field are exposed to the high costs associated with such accidents. These costs are diverse in nature, and include human costs (which are not directly quantifiable) and financial, for the companies in the industry and for society as a whole (sick leave, medical treatment, etc.) (Abudayyeh et al., 2006; Dorman, 1997). In parallel, other costs are associated with delays in project implementation times, damage to the company's reputation or the loss of market share (Gosselin, 2005; Jallon et al. 2011a,b).

According to Rikhardsson (2005), managerial or management accounting is called upon to play an active role in project evaluation, strategic planning and relationships with stakeholders, thus extending the impact and scope of the methods and techniques applied in this field. One such case is that of the management of safety risk in the workplace, where managerial accounting can provide valuable information for decision-making by internal users and for managing relationships with stakeholders.

As stated by Tappura et al. (2015), the management accounting approach is an essential factor in managerial decision-making to safety work, especially to provide information for organisation, when they make investment in safety.

As observed by Bhimani (2009:2), the relationship between management accounting and risk management has been addressed to a minimal extent in the academic literature. However, "the potential of risk concepts to be made managerially actionable rests on their capacity to be interpreted in technical, analytical and calculable terms", and . . ."enterprises seek not only to adopt risk controls but also to make the deployment of such controls transparent and visible to engender greater organisational legitimacy". Berry et al. (2009) raise relation between management control and risk management as an emerging theme in management control research. In this sense, Esmaeili and Hallowell (2012) propose new research areas that may enhance safety performance, as integration of safety data into building information models and utilising leading indicators of safety performance, among others (Hallowell et al., 2013; Hassanein and Hanna, 2008; Ikpe et al.,

* Corresponding author at: Department of Accounting and Finance, Faculty of Economics and Business Studies, University of Granada, C/Campus Universitario de Cartuja, s/n, 18071 Granada, Spain. Tel.: +34 651 95 22 10, +34 958 24 96 20.
E-mail addresses: pdavila@ugr.es (M.P. Ibarrondo-Dávila), mlopeza@ugr.es (M. López-Alonso), mcrubio@ugr.es (M.C. Rubio-Gámez).

http://dx.doi.org/10.1016/j.ssci.2015.05.014
0925-7535/

2012; Ku and Mills, 2010). In addition, research into the cost effectiveness of safety practices would help practitioners to build strong programs with limited budgets (Hinze et al., 2013).

According to Cullen et al. (2013), taking a management accounting practice perspective, researches can innovate and lead the way to practitioners. Such research is important in terms of both theoretical contribution and practical relevance.

Zou et al. (2014:325) have observed that there may be a gap between the knowledge generated by researchers and the practical needs in the construction industry, about safety. These authors have advocated the greater use of mixed methods research design to integrate the realms of theory and practice to improve the relationships between researchers and practitioners in construction safety. "By adopting this approach, it is expected that research findings will become more relevant and useful to construction industry and practitioners, while at the same time contributing to the advancement of conceptual understanding and theory development".

From this perspective, our paper seeks to provide an illustration of management accounting practice and its importance to improve safety risk management systems in companies. As suggested by Cullen et al. (2013), this paper is raised as an interventionist research, undertaken by interdisciplinary research teams (management accountants and engineers, as researchers, and risk prevention managers, as practitioners of construction companies).

In this sense, taking into account the above considerations, this paper describes the background to the management of health and safety costs in the workplace, highlighting the difficulties faced and the reluctance of companies to include these items systematically in their accounts. We then propose an accounting model for the calculation, analysis and control of safety costs in companies, which could be incorporated into their information systems, with particular reference to construction companies. This model is the outcome of the research study of a sample of 40 construction sites in Andalusia (Spain), at different stages of progress, in 2008. Finally, we present a case study in a Spanish construction company concerning two of these construction projects that were taking place when the data were compiled.

2. Background

Workplace accidents (including incidents and minor accidents) can have severe financial consequences for companies (Feng et al., 2015; Hinze and Appelgate, 1991), as well as impacting on society and on the workers concerned.

Investment in health and safety is usually made in response to a specific motivation. According to Heinrich (1930), employers have two reasons for seeking to prevent accidents: firstly, a moral and legal obligation related to accident insurance; and secondly, contractual obligations with their employees. In the same vein, Brody et al. (1990) identify three motivations for investing in health and safety measures: a voluntary motivation, aimed at improving work procedures; a motivation related to Social Security incentives, such as insurance premium discounts available to companies presenting low rates of workplace accidents; and a coercive motivation, related to penalties imposed under labour law and regulations.

Other authors, however, believe that the most important motivation for companies to invest in health and safety is that of the high cost of accidents (Laufer, 1987; Levitt and Parker, 1976; Simmonds and Grimaldi, 1963). In contrast, Dorman (2000) argues that construction companies meet the costs of health and safety measures not only to improve working conditions and to reduce accident rates, but also to avoid sanctions, to obtain social benefits, to enhance the corporate image and for the sake of other future benefits.

In any case, the above authors all concur that health and safety costs do exist and that they are substantial. However, they also agree that such costs are not so onerous for financial motivations to be considered the sole reason for a company deciding to invest in health and safety.

Various authors have highlighted the lack of consensus as to how the costs of health and safety should be addressed in company accounts. Reasons for this include the difficulty encountered in expressing employees' health in money terms (Andreoni, 1986), the limitation of dealing with normal market economy mechanisms, the question of safety and health as a public good (Bailey et al., 1995) and the widespread underestimation of these costs by companies (Brody et al., 1990).

Other possible causes of this shortcoming in business management are the extra workload perceived, the reluctance to change established accounting methods or the limited importance granted to health and safety departments within companies (Jallon et al. 2011a,b). According to Gosselin (2005), the calculation methods proposed by researchers for assessing the indirect costs of health and safety measures in the workplace are neither universal nor generalizable.

These considerations lead us to conclude that there is little interest among companies in identifying the costs concerning health and safety at work. This belief is confirmed by the results obtained in Spain by the National Survey on the Management of Health and Safety at Work (INSHT, 2009) in relation to companies in the construction sector.

The above conclusion is corroborated by empirical research based on questionnaires concerning 40 construction sites in Andalusia between 2007 and 2008, addressed to various companies in this sector. Our analysis makes it clear that safety costs are not calculated, and therefore are not controlled, by these companies.

From this perspective, construction firms would be more likely to invest in improving their workplace health and safety systems if they had an information system based on a model for the calculation, analysis and control of safety costs, and which highlighted the benefits to be derived from investing in safety, as recommended by the National Institute for Health and Safety at Work (INSHT, 1999).

In order to manage safety costs, it is necessary to take into account the activities that influence them. However, under standard accounting practice in construction companies, the items that comprise these costs are not identified. Most of the concepts involved are included in different accounting items, and the impact of each one on the income statement remains unknown (Aaltonen et al., 1996; Argilés-Bosch et al., 2014; Oxenburgh and Marlow, 2005; Riel and Imbeau, 1996; Rikhardsson, 2004).

Managerial accounting, as an information system for management, can play a vital role in this respect, by systematically providing appropriate reports to support the decision-making process in the area of health and safety at work. These data are valuable not only for those responsible for safety management in the company, but also for managing relations with diverse stakeholders, such as the company's employees and public institutions in the field of health and safety.

Awareness of the nature and dimension of safety costs is of great importance for risk management within companies.

3. Methodology

3.1. Designing a model for managing safety costs in construction projects: HSC_PEI2012

In order to design a model for managing safety costs, it is first necessary to define the categories of safety cost that constitute

useful *cost objects* for decision making in the area of risk prevention. When appropriate items have been obtained, the company's accounting information system should be adapted accordingly so that data may be compiled and information provided on the cost objects in question.

With respect to cost categories, there are strong parallels between managing quality-control costs and managing health and safety costs, although the latter present certain special characteristics.

In this respect, our proposed classification, following Andreoni (1986) and Brody et al. (1990), distinguishes between the costs incurred in implementing risk prevention measures in the workplace and those caused by the absence of such measures and by accidents, i.e. what the latter authors term *prevention cost* and *accident cost*. However, a more profound analysis of the cost elements that make up each of the above categories leads us to propose a different approach to the delimitation and classification of workplace safety costs.

In this study, the costs related to health and safety for construction companies are defined as the consumption value of factors of production (goods and services) required by the company to improve working conditions and to reduce accident rates on construction sites, together with the costs derived from the occurrence of incidents and/or accidents.

The costs related to workplace health and safety are classified as follows:

Safety costs: the costs incurred to ensure health and safety in the workplace, differentiating between *prevention costs*, i.e. the preventive measures necessary to ensure appropriate health and safety conditions, and *evaluation and monitoring costs*, derived from the actions taken by the company to inspect and maintain the health and safety measures implemented in the workplace.
Non-safety costs: the costs of failing to ensure health and safety in the workplace, i.e. the costs to the company that arise from incidents and accidents, and/or from breaches of safety rules. In turn, we distinguish between *tangible costs*, produced directly by a specific accident, and which can be quantified by conventional calculation methods, and *intangible costs*, which are not measurable in financial terms or for which there are no suitable performance indices to measure their impact on the firm. Intangible costs include damage to the company's reputation, low morale among employees, labour disputes and loss of market share (Gosselin, 2005).
Extraordinary costs: this category includes the losses generated by events that cannot be controlled by technical or human management in construction projects, or that are unavoidable, such as natural disasters. In our view, this cost category should include all cost items that are outside the scope and control of management, and so they are configured as *uncontrollable costs*, not to be included in a structured model aimed at the control of costs related to safety in the workplace.

Tables 1–4 describe the different concepts that could be included in the categories of Prevention Costs, Evaluation and Monitoring Costs and Non-Safety Costs, in the case of a construction company.

In each of the health and safety cost categories identified as distinct cost objects, direct and indirect costs may be incurred, depending on the nature of the item in question, on the characteristics of the company's accounting information system and on the inherent limitations of the data collection process. Furthermore, the basic unit of analysis, taken as a reference for calculating the health and safety cost impact on construction companies, is each *construction project planned and/or executed*.

3.2. Allocation of safety costs

After identifying appropriate categories of health and safety costs, with respect to the cost objects on which the cost allocation process will be focused, we propose a methodology, based on economic and accounting reasoning, and especially on the principles of cost accounting, with which to identify, measure and quantify the different cost items that make up each of the cost objects we have defined, namely *prevention costs, evaluation and monitoring costs* and *tangible non-safety costs*.

This proposal does not address the question of calculating the intangible cost of accidents. The initial basic model considers the safety costs that can be identified by applying traditional cost accounting methods. Once the model is running and information

Table 1
Prevention costs in construction companies.

Prevention costs	Concepts
Trainings	Cost of training time Training Department costs: preparation and implementation of training programmes; staff salaries; preparation of documents Awareness-raising campaign for employees and compliance checks Specific external training
Health and safety measures: hygiene and well-being facilities	Installation of staff changing rooms, bathrooms and lavatories; re-fitting and subsequent maintenance
Personal protective equipment	Equipment required for each worker, in accordance with the functions performed
Collective protective equipment	Appropriate measures of collective protection, suited to the activity to be performed and aimed at eliminating or reducing the risks involved
Health and safety signs	Cost of the elements installed to provide health and safety information or in accordance with regulatory obligations
General expenses or the costs of supplies	Production factors (such as water or electricity) that the company acquires externally and which are needed to carry out risk prevention activities
Staff health and safety costs	Staff costs of the health and safety department, responsible for the assembly, maintenance and removal of collective protection equipment, and for cleanliness and tidiness on the site
Health and safety administration costs	Costs of materials for documenting risk prevention activities: preventive action schedules, health and safety programmes, delivery receipts of personal protective equipment, incident and subcontracting logs
Health monitoring	Costs of initial, periodic and specific medical examinations for employees, and of special medical tests
Risk prevention department	Salaries and other costs for the risk prevention service staff Service contract costs when the risk prevention service is outsourced. Cost of machinery and equipment for specific analyses
Social security payments and liability insurance for employees and third parties	Total cost of companies' Social Security payments to maintain employees' salaries in the event of accident or occupational illness
Monitoring and organisation of business activities	Cost of coordination meetings for staff, managers and external agents to organize risk prevention actions

Table 2
Evaluation and monitoring costs in construction companies.

Evaluation and monitoring costs	Concepts
Visits by risk prevention service technical staff	Cost of corrective actions proposed to improve health and safety conditions Loss of work hours by construction workers accompanying labour inspectors Time required by risk prevention service staff
Labour Inspectorate visits	Cost of corrective actions proposed to improve health and safety conditions. Loss of work hours by construction workers during visit by labour inspectors
Visits by other technical staff employed by public bodies	Cost of corrective actions proposed to improve health and safety condition Loss of work hours by construction workers Cost of preparing the reports required by the risk prevention service staff
Visits by health and safety coordinators	Cost of corrective actions proposed to improve health and safety conditions Loss of work hours by construction workers Cost of preparing the reports required by the risk prevention service staff
Equipment maintenance	Cost of the maintenance and repair of the equipment and machinery required for risk prevention
Preparation of technical reports	Cost of evaluating specific situations by any of the agents involved in risk prevention
Appeals against sanctions imposed for the breach of health and safety requirements	Cost of administrative sanctions for non-compliance Cost of the risk prevention staff responsible for remedial actions required by the inspection
Studies of working conditions, questionnaires, workshops, etc.	Cost of campaigns to improve working conditions

Table 3
Tangible Non-safety costs in construction companies.

Tangible costs	Calculation basis (adapted from INSL (2003))
Accident victim costs	
Medical, pharmaceutical and transfer costs of the accident victim	Amounts billed and not covered by the Social Security
Compensation	Compensation paid as a result of the accident and not covered by the Social Security
Staff costs	
Work hours lost by the accident victim	For each employee: No. of hours lost × hourlycost
Work hours lost by other staff	For each employee: No. ofhourslost × hourly cost
Work hours lost by managers	For each employee: No. of hours lost × hourly cost
Discretionary pay supplements in case of temporary incapacity. Social Security only covers 75% of the regulatory base. A sector-wide wages agreement may state that the remaining 25% of the regulatory base (or the total salary) must be covered by the company	No. of days' sick leave × daily amount of the supplement
Social Security contribution (not suspended during short-term occupational incapacity)	No. of days' sick leave ×daily Social Security contribution
Costs for material damage	
Repair by external services of damage to premises and installations	Invoice
Repair by internal services of damage to premises and installations	No. of hours required ×hourly cost
Materials employed to repair damage to premises and installations	Store units employed × unit cost, or invoice amount
Damaged raw materials	No. of damaged units × unit cost
Finished products ready for sale or processing	No. of damaged units × unit cost
Machinery downtime	For each machine: Downtime × hourly hiring or amortization cost
Cost increase incurred in maintaining production level	Overtime: Extra hours × hourly cost Recruitment of replacement workers: Extra hours worked × hourly cost + staff selection costs + replacement staff training costs + contracting and subcontracting of work and services: total invoiced
Other costs	
Costs of measures taken to prevent similar accidents from occurring in the future	Invoices for new protection elements Cost of training campaign to prevent similar accidents from occurring in the future
Cost of judicial proceedings	Invoices of lawyers and attorneys (if provided by external services) or of travel expenses and allowances (if the company has its own legal advisory services)
Administrative liability	Cost of administrative sanctions and/or the cessation or interruption of work and/or restrictions on eligibility to obtain future public procurement contracts
Social Security liability	Benefits surcharge: 30–50% increase in the compensation paid for workplace accidents or occupational diseases due to inadequate health and safety measures Increase or decrease in Social Security premiums due to workplace accidents and occupational diseases
Civil liability	Any occurrence producing criminal responsibility also produces civil liability (Article 16 of the Criminal Code)
Contractual civil liability	Financial compensation for the injury caused to the worker if it is consequential of non-compliance with a contractual obligation
Non-contractual civil liability	Responsibility for damage due to culpable action or omission, without previous contractual relationship
Fees paid to technical experts and lawyers	Invoices presented by technical experts and lawyers
Penalties for delay	Lost client confidence; possible complaint of non-compliance with contractual obligations concerning execution time, liability according to contractual administrative clauses

Table 4
Intangible non-safety costs in construction companies.

Intangible costs	Calculation basis
Damage to company reputation Loss of market share Costs arising from possible labour disputes Reduced morale among employees	By analysis of impact on the company and estimation of its monetary value

is being obtained on a regular, systematic basis, the company could incorporate the estimation of intangible safety costs into the system. In this respect, some studies have been performed, such as that conducted by the National Institute for Health and Safety at Work (INSHT, 2003).

3.2.1. Direct and indirect costs

From the standpoint of cost allocation, a distinction is made between *direct costs* and *indirect costs*.

The *direct cost of safety* corresponds to the consumption of goods and services that can reasonably – in technical and financial terms – be identified with the cost object. In other words, it reflects the cost entry whose final impact on the cost object within each of the safety cost categories can be determined, in relation to each construction project. In order to determine this cost, it must be possible to establish a clear cause-effect relationship between the consumption of resources and the corresponding safety cost category. But in addition, the company's information system and data collection procedure must be designed in such a way as to facilitate the identification of such cause-effect relationships. Some safety cost concepts are readily identifiable with the corresponding cost category, and can thus be considered *direct costs* concerning the cost object for which a cause-effect relationship is known.

On the other hand, *indirect safety costs* are those which must be attributed to cost categories on a pro-rata basis, because it is not possible to directly determine their specific impact on the constitution of safety costs.

To illustrate the above distinction, the *direct costs* of the category *prevention costs* for a construction project might include the cost of installing huts for changing and toilet facilities for the workers, or those arising from the application of collective protection measures. In both situations, this is assuming that the measures in question are implemented by contracting an external service to this effect, in which case the cost of the service received would be clearly identified on the invoice issued by the company providing the service, and would thus constitute a prevention cost directly assignable to the site at which the contracted services are provided.

If an accident occurred, the *direct costs* of this event would include certain tangible cost items, such as the work time lost by the victim or by other workers, the cost of equipment repairs carried out by an external service, or the cost of products damaged in the accident.

An example of *indirect costs* would be, in the case of *prevention costs*, those related to training, which spans many different areas, such as awareness campaigns, the cost of external training aimed at all the company's employees, or the cost of the training department itself. None of these items arise from a preventive measure directly attributable to a specific project, but to the company as a whole, and therefore the risk prevention cost for each project requires a pro-rata criterion to be applied.

Similarly, *indirect evaluation and monitoring costs* would include some of the costs of site visits by technicians employed by internal risk prevention services, such as those relating to the risk prevention department itself, as its activity is not directed exclusively at any specific project, but at all those performed by the company. Accordingly, in this case, too, a pro-rata calculation must be made.

3.2.2. Cost allocation to safety cost objects

Direct costs can be identified to each of the categories defined by developing a protocol for data collection within the company, clearly setting out the procedures to be followed, in each case, to identify cost items with the corresponding cost object. The number of resource units applied and their unit cost should be specified, and the use made of these resources will be the safety cost object in question (prevention cost, evaluation and monitoring cost or tangible non-safety cost).

On the other hand, *indirect costs* must be allocated to cost objects using a pro-rata criterion. In this respect, the application of methodologies developed for responsibility centre models of cost calculation provides a satisfactory solution. In these models, *cost centres*, which constitute the organisational structure of the company, facilitate the allocation of indirect costs to cost objects and enable managers to monitor the company's activities in general and prevention activities in particular.

The area of the company that is most clearly related to a safety cost object is the *Risk Prevention Department*. Therefore, we must analyse the composition of this department and the role it plays within the company, in order to highlight the relationship between its activities and the safety cost categories defined in relation to each construction project.

In performing its functions, the Risk Prevention Department generates a cost derived from the various productive factors required for this activity. Accordingly, the costs incurred by the department must be identified. Basically, these correspond to its own staff, the materials used, the external services received, the stores consumed and the computer equipment needed. Having identified these costs, they are then charged to specific cost objects, depending on the unit of measurement of the department's activity considered to be most representative of the cost incurred.

The diversity of functions performed by the Risk Prevention Department makes it difficult to determine a homogeneous unit of measurement that is representative of all the various activities carried out. In practice, each company must conduct its own study of the costs incurred by this department and of the possible units of measurement to assess its activity over a prolonged period, in order to choose the unit that best correlates with these costs. Possible units for this purpose include the number of hours worked by senior departmental managers, the number of reports issued, the number of incidents responded to, the number of accidents investigated, etc.

Once the cost of the Risk Prevention Department has been calculated, and a suitable unit of measurement of its activity chosen, the cost of the activity unit can be determined, as the ratio between the department's costs and the number of activity units corresponding to the calculation period, according to the following formula: $k_{PD} = TK_{Pd}/U_{PD}$, where k_{PD} = cost of the activity unit chosen for the Risk Prevention Department in the period; TK_{PD} = total cost calculated for the Risk Prevention Department in the period; and U_{PD} = number of activity units employed during the period.

Finally, the cost corresponding to the Risk Prevention Department is assigned to the different safety cost objects determined for each project, by multiplying the number of activity measurement units, consumed by each of the cost objects identified, by

the unit cost of the activity unit in the period considered. Thus, for cost object i, corresponding to project j, the cost for a particular period, for the activity carried out on its behalf by the Risk Prevention Department, would be obtained from the following expression: $K_{i,j} = u_{i,j} \times k_{DP}$, where $K_{i,j}$ = cost assigned to safety cost object i, corresponding to project j, for the activity carried out on its behalf by the Risk Prevention Department; and $u_{i,j}$ = the number of activity units received from the Risk Prevention Department by safety cost object i, corresponding to project j.

If the company has an advanced information system that provides reliable data, broken down by areas, activity-based costing could be used to allocate indirect health and safety costs among the different activities identified in relation to the risk prevention system, or to the occurrence of an accident, as proposed by Rikhardsson and Impgaard (2004) and by Riel and Imbeau (1995, 1996, 1998).

3.3. Indicators and reports for health and safety management

The fundamental aim of the model proposed for the calculation, analysis and control of safety costs in construction companies is to obtain information, primarily financial in nature, on health and safety costs in each project undertaken, and to make this information available to company managers with responsibilities in this area, in order to support the decision-making process and to facilitate relationships with stakeholders.

Tables 5 and 6 show a standard report format; the first of these concerns safety costs (*prevention*, and *evaluation and monitoring*), and the second refers to tangible and intangible non-safety costs.

With respect to the development of health and safety indicators, for maximum effectiveness these should be designed jointly by workers or their representatives, specialists in health and safety at work, financial experts and decision-takers at different levels of responsibility. The information summarised by these indicators should be understandable, straightforward and manageable, to facilitate its communication at all levels of the business organisation and to contribute to its subsequent development (Miyakawa et al., 2011).

Table 7 shows, as an example of this, a series of indicators, both monetary and non-monetary, depending on whether they relate to variables that can be measured in monetary units or not, that are applicable in the field of workplace health and safety in construction companies.

4. A case study. Application of the *HSC_PEI2012* model to a Spanish company: construction projects CE/28/1/2-10 and MA/1/8/30-07-07

In this section we address, as a case study, the application of the proposed model for the calculation, analysis and control of safety costs in construction companies to Project No. CE/28/1/2-10, which forms part of the sample considered in an empirical study conducted in Andalusia (Spain), and presents the following characteristics:

Public-sector building construction project.
Implementation period: 48 months.
Contract award discount: 12.2%.
Implementation budget: €47,781,947.03.
Number of accidents: 12.

The following tables present an analysis of safety costs, comparing the data obtained by the company's present management system with the information that could be derived from the proposed model for the calculation, analysis and control of these costs.

This calculations have been got applying the proposed model. The input data have been obtained directly from the worksites. The information was available in different sections in the accounting system. Based on this information, we have been able to estimate an important part of prevention costs, evaluating and monitoring costs and other tangible costs as it was defined in Tables 1–3. However, to get the appropriate data to calculate total safety costs, it would have been first necessary implement the model in the economic information system of the company, by applying the methodology shown in Section 3.2.

Specifically, Table 8 compares the prevention costs identified by the current system and the costs that could be identified under the proposed model. Table 9 presents a similar comparison of monitoring and evaluation costs. These analyses are based on the data obtained from a survey conducted at the construction site in question and on the elements of the model proposed. The tangible costs of accidents were calculated using the model proposed by the Navarre Institute of Occupational Health (INSL, 2003), based on Risk Prevention Technical Note 273 published by the National Institute for Safety and Health at Work (INSHT, 1991), which has been used as a benchmark by several studies carried out in Spain, at an overview level, including work by the INSHT

Table 5
Monthly summary report of safety costs.

Summary report of safety costs for January 201X (Euros)								
Concept	Current month				Accumulated to date			
	Safety costs		As % of		Safety coasts		As % of	
	Budget	Real	SPB[a]	IB[b]	PREV.	Real	SPB[a]	IB[b]
1 Risk prevention costs								
1.1 Employee training								
1.2 Health and safety measures								
1.3 Health and safety staff								
1.4 Risk Prevention Department								
1.5 Social Security and civil liability insurance								
Total risk prevention costs								
2 Evaluation and monitoring costs								
2.1 Internal visits								
2.2 External visits								
2.3 Equipment maintenance								
2.4 Technical reports								
Total evaluation & monitoring costs								
Total health & safety costs (1) + (2)								

[a] SPB = Safety Plan Budget.
[b] IB = Implementation Budget.

Table 6
Monthly summary report of non-safety costs.

Summary report of non-safety costs for January 201X (EUROS)						
Concept	Current month			Accumulated to date		
	Safety costs	As % of		Safety costs	As % of	
		SPB[a]	IB[b]		SPB[a]	IB[b]
3 Tangible costs of accidents						
3.1 Direct costs						
3.2 Indirect costs						
Total tangible costs of accidents						
4 Intangible costs of accidents						
4.1 Damage to company reputation						
4.2 Loss of market share						
4.3 Loss of output						
4.4 Labour conflict and reduced morale						
Total intangible costs of accidents						
Total non-safety costs (3) + (4)						

[a] SPB = Safety Plan Budget.
[b] IB = Implementation Budget.

Table 7
Health and safety indicators.

Indicator	Type	Purpose	Calculation formula	Evolution
Prevention cost: implementation budget	Monetary	To analyse the cost of collective and individual safety measures per € of implementation budget	$\frac{PC}{IB}$	Analyse the monthly evolution of the indicator
Evaluation and monitoring cost: implementation budget	Monetary	To analyse the cost of evaluation and monitoring per € of implementation budget	$\frac{EMC}{IB}$	Analyse the monthly evolution of the indicator
Accident costs: implementation budget	Monetary	To analyse the cost of accidents per € of implementation budget	$\frac{CACC}{IB}$	Analyse the monthly evolution of the indicator
Prevention costs: total safety costs	Monetary	To analyse the cost of collective and individual safety measures per € of total safety costs	$\frac{PC}{SC}$	Analyse the monthly evolution of the indicator
Evaluation and monitoring costs: total safety costs	Monetary	To analyse the cost of evaluation and monitoring per € of total safety costs	$\frac{EMC}{SC}$	Analyse the monthly evolution of the indicator
Accident costs: total safety costs	Monetary	To analyse the cost of accidents per € of total safety costs	$\frac{CACC}{SC}$	Analyse the monthly evolution of the indicator
Accident rates: total safety costs	Mixed	To analyse the number of accidents per € of total safety costs	$\frac{No.\ of\ accidents}{SC}$	Analyse the monthly evolution of the indicator
Breaches of safety regulations: total safety costs	Mixed	To analyse the number of breaches or amendment requirements per € of total safety costs	$\frac{No.\ of\ breaches}{SC}$	Analyse the monthly evolution of the indicator
Sanctions: total safety costs	Monetary	To analyse the cost of sanctions or amendment requirements per € of total safety costs	$\frac{Cost\ of\ sanctions}{SC}$	Analyse the monthly evolution of the indicator

National Centre for Working Conditions (2001), the Basque Institute of Occupational Health (OSALAN, 2005) and the La Rioja Institute of Occupational Health (IRSAL, 2008).

In relation to the tangible non-safety costs, the present economic information system used by the company does not identify the various cost items arising from the occurrence of an accident. In contrast, the proposed model, as shown in Table 3, provides detailed information on the various cost items related to the accident. Its application to the project considered, according to the information obtained in the survey, would produce a cost in this respect of €21,448.85.

Table 10 summarises the calculations made relating to safety costs, in the project considered for this purpose, showing the difference between the total safety cost produced by the economic information system currently used by the company and that which would be obtained by the proposed model. The real differences would probably be significantly greater, taking into account that most of the cost obtained by the present system corresponds to the costs allocated by the company's central services, an allocation that is made arbitrarily, based on a percentage established by senior management, regardless of the cause-effect relationships pertaining to the cost of risk prevention in the company. Furthermore, in this application of the proposed model to the construction project described, we were unable to quantify many of the concepts in the area of safety costs, due to the absence of appropriate data. This issue would be resolved with the implementation of a model for the analysis, calculation and control of safety costs in the company, such as that proposed in this study.

In order to be able to compare with another case, Table 11 shows other construction project, where we have applied the HSC_PEI2012 model. The selected project has been MA/1/08/30-07-2007, that belongs to the same sample from the research study previously carried out in Andalusia (Spain). The descriptors of this construction project were the following:

Private construction of one-family houses.
Completion time: 22 months.
Contract award discount: 0.0%.
Budget implementation: 35.844.000, 00 €.
Number of accidents: 8.

As shown in Table 11, the results are similar to the previous case, shown in Table 10, where more than 90% of the total safety costs remain invisible to company managers.

Table 8
Prevention cost. Application of the proposed model to Project No. CE/28/1/2-10.

Prevention cost	Costs identified by the present economic information system	Costs identified using the proposed model
Training of workers	Training costs	Training costs
Risk Prevention Department	In the present economic information system, the cost of this department is distributed as a percentage applied equally to all projects. This percentage is applied to the costs of central services, including the Training Department, and varies between 4% and 6% of the project implemented during the month. In the case in question, the amount was €**39818.29**	In the proposed model, the specific cost of the Training Department would be calculated and its distribution would be based on the activity unit in question. No information is available on this calculation for the project specified. In addition, the cost for the training hours dedicated to each worker would be computed. No information is available on this calculation for the project specified
Health and Safety Measures: hygiene and welfare facilities	Risk Prevention Department costs	Risk Prevention Department costs.
Individual protective equipment	In the present economic information system, the cost of this department is distributed as a percentage applied equally to all projects. This percentage is applied to the costs of central services, including the Risk Prevention Department, and varies between 4% and 6% of the project implemented during the month. In the case in question, it is included in "% of local management costs", quantified at 2.5% of the production achieved during the month, and amounted to €**24886.43**	In the proposed model, the specific cost of this department would be calculated and its distribution would be based on the activity unit in question. No information is available on this calculation for the project specified
Collective protective equipment	Other items (Health and safety measures; individual and collective protective equipment, ...)	Health and Safety Measures
Health and safety signs	No further detailed economic information is available. The cost is dispersed among various entries in the income statement for the project or at the overall company level.	The proposed model would provide differentiated information in this respect. In the present project, rented site huts are installed, at a monthly cost of €**43350.00**
Supplies and overheads		Individual protective equipment
Health and safety personnel costs		The proposed model would provide differentiated cost information in this respect. The invoice amount in question is €**73585.61**
Health and safety administration costs		Collective protective equipment
Health monitoring		The proposed model would provide differentiated cost information in this respect. The invoice amount in question is €**851010.94**
Social security, civil liability and workers' insurance		Other items
Monitoring and organisation of business activities		The proposed model would provide differentiated cost information in this respect. For direct costs, via the data compilation protocol. For indirect costs, on a pro-rata basis. No information is available on this calculation for the project specified.
Total prevention cost	64704.72	967946.55

Table 9
Evaluation and Monitoring costs. Application of the proposed model to Project No. CE/28/1/2-10.

Evaluation and monitoring costs	Costs identified by the present economic information system	Costs identified using the proposed model
Visits by Risk Prevention Department technicians	Cost of administrative sanctions for non-compliance	Cost of administrative sanctions for non-compliance
Views by the Labour Inspectorate	In this case, two administrative sanctions were recorded, of €**6010.12** and €**3600.00**, respectively	In this case, two administrative sanctions were recorded, of €**6010.12** and €**3600.00**, respectively
Visits by other public-sector technicians	Other items	Other items
Visits by Health and Safety Coordinators	No further detailed economic information is available. The cost is dispersed among various entries in the income statement for the project	The proposed model would provide differentiated cost information in this respect. For direct costs, via the data compilation protocol. For indirect costs, basically through the Risk Prevention Department (the specific cost of the Department would be calculated and this would then be allocated according to the activity unit in question)
Equipment maintenance		No information is available on this calculation for the project specified
Preparation of technical reports		
Sanctions for the absence of health and safety measures		
Studies of working conditions, surveys, workshops, etc.		
Total evaluation & monitoring costs	9610.12	9610.12

Table 10
Safety costs. Application of the proposed model to Project No. CE/28/1/2-10.

	Current system	Proposed model	Difference
Prevention cost	64704.72	967946.55	903241.83
Evaluation and monitoring cost	9610.12	9610.12	–
Tangible non-safety cost		21448.85	21448.85
Total safety cost	74314.84	999005.52	924690.68
% of total estimated safety cost	7.44%	100%	92.56%

Table 11
Safety costs. Application of the proposed model to Project No. MA/1/8/30-07-07.

	Current system	Proposed model	Difference
Prevention cost	105902.73	191388.51	85485.78
Evaluation and monitoring cost	15728.88	1408578.49	1392849.61
Tangible non-safety cost		3676.39	3676.39
Total safety cost	121631.61	1603643.39	1482011.78
% of total estimated safety cost	7.58%	100.00%	92.42%

5. Discussion

The tradition of utilising methods of Management Accounting is not well-established in safety management of organisations (Tappura et al., 2015). However, construction firms would be more likely to invest in improving their workplace health and safety systems if they had an information system based on a model for the calculation, analysis and control of safety costs, and which highlighted the benefits to be derived from investing in safety.

In order to manage safety costs, it is necessary to take into account the activities that influence them. However, under standard accounting practice in construction companies, the items that comprise these costs are not identified. Most of the concepts involved are included in different accounting items, and the impact of each one on the income statement remains unknown (Aaltonen et al., 1996; Argilés-Bosch et al., 2014; Oxenburgh and Marlow, 2005; Riel and Imbeau, 1996; Rikhardsson, 2004). The case study presented in this work shows some examples of these costs, such as the health and safety measures or the individual and collective protective equipment, as indicated in Table 8.

As Argilés-Bosch et al. (2014) recommend, firms have to devote resources and management accounting techniques for assessing the true economic consequences of labour accidents. Moreover, this information could contribute to provide a picture of the firm's social responsibility and its implication with occupational health safety, providing relevant information for stakeholders.

On the other hand, Feng (2013) found that safety investments have a stronger positive effect on accident prevention under a higher safety culture level. In this sense, an appropriate safety management information system could be a good opportunity for enhancing safety culture in organisations (Fenández-Muñiz et al., 2009). Fernández-Muñiz et al. (2009) found that safety management system has a positive effect on competitiveness performance. Likewise, the more developed the system is, the higher the productivity, as a consequence of the reduction in costs caused by accidents. Furthermore, they found that the more advanced the management system implemented, the more satisfied the organisations are with their economic indicators.

Managerial accounting, as an information system for management, can play a vital role in this respect, by systematically providing appropriate reports to support the decision-making process in the area of health and safety at work (Argilés-Bosch et al., 2014; Tappura et al., 2015). Awareness of the nature and dimension of safety costs is of great importance for risk management within companies.

6. Conclusions

Among other functions, management accounting should provide, in a systematic fashion, appropriate reports to facilitate the decision-making process regarding risk prevention, for both external and internal stakeholders.

For this purpose, the first step is to design an appropriate management accounting model, that it be able to provide reliable and usable information about safety costs. In designing a system of managerial accounting to control costs related to health and safety at work, we must first determine the *cost objects* that are useful for decision making in this field. Accordingly, we propose the following cost classification:

- *Safety costs*, consisting of two components: *prevention costs* and *monitoring* and *evaluation costs*.
- *Non-safety costs*, also consisting of two components: tangible and intangible costs.

Each of the safety cost categories identified as distinct cost objects may include direct and/or indirect costs, depending on the nature of the item in question, the characteristics of the company's accounting information system and the limitations of the data collection process.

The *direct cost* for each of the categories defined could be identified through the development of a data collection protocol for the company, clearly setting out the procedures to be followed, in each case, to identify the cost items with the corresponding cost objects.

The *indirect costs*, on the other hand, could be allocated to the cost objects by applying the methodology derived from responsibility centre accounting.

When appropriate cost items have been defined and a suitable cost allocation methodology adopted, the necessary modifications must be made to the accounting information system, for data compilation and the provision of information on the selected cost objects.

The application of the management accounting model proposed to a case study in a Spanish company, in two construction projects, has shown that companies face substantial health and safety costs and that to a very large extent these remain invisible to company managers. In the construction projects examined here, these hidden costs represent more than 90% of the total safety costs.

Model HSC_PEI2012 provides quantitative information that is of great value for decision-making in the company in relation to the

management of health and safety, and can contribute to improving safety risk management process on construction sites.

A limitation of this study is that the model has been partly applied only in two construction projects in a one company. For further research, it would advisable to implement the model HSC_PEI2012 in various construction projects and compare the safety costs data and the indicators obtained.

References

Aaltonen, M.V.P., Uusi-Rauva, E., Saari, J., Antti-Poika, M., Räsänen, T., Vinni, K., 1996. The accident consequence tree method and its application by real-time data collection in the Finnish furniture industry. Saf. Sci. 23, 11–26.

Abudayyeh, O., Fredericks, T.K., Butt, S.E., Shaar, A., 2006. An investigation of management's commitment to construction safety. Int. J. Project Manage. 24, 167–174.

Andreoni, D. (Ed.), 1986. The Cost of Occupational Accidents and Diseases, International Labour Office, Geneva.

Argilés-Bosch, J.M., Martí, J., Monllau, T., García-Blandón, J., Urgel, T., 2014. Empirical analysis of the incidence of accidents in the workplace on firms' financial performance. Saf. Sci. 70, 123–132.

Bailey, S, Jorgensen, K, Koch, C, Krüger, W and Litske H., 1995. An Innovative Economic Incentive Model for Improvement of the Working Environment in Europe. Office for Official Publications of the European Communities. Luxembourg. <http://www.eurofound.europa.eu/pubdocs/1995/18/en/1/ef9518en.pdf> (accessed 20.08.2008).

Berry, A.J., Coad, A.F., Harris, E.P., Otley, D.T., Stringer, C., 2009. Emerging themes in management control: a review of recent literatura. British Acc. Rev. 41, 2–20.

Bhimani, A., 2009. Risk management, corporate governance and management accounting: emerging interdependencies. Manage. Acc. Res. 20, 2–5.

Brody, B., Létourneau, Y., Poirier, A., 1990. An indirect cost theory of work accident prevention. J. Occup. Acc. 13, 255–270.

Chi, S., Han, S., 2013. Analyses of systems theory for construction accident prevention with specific reference to OSHA accident reports. Int. J. Project Manage. 31, 1027–1041.

Cullen, J., Tsamenyi, M., Bernon, M., Gorst, J., 2013. Reverse logistics in the UK retail sector: a case study of the role of management accounting in driving organisational change. Manage. Acc. Res. 24, 212–227.

Dorman, P., 1997. Internalizing the costs of occupational injuries and illnesses: challenge or chimera?. In: Mossink, J., Licher, F. (Eds.), Costs and Benefits of Occupational Safety and Health: Proceedings of the European Conference on the Costs and Benefits of Occupational Safety and Health, The Hague.

Dorman, P., 2000. The Economics of Safety, Health, and Well-Being at Work: An Overview. In Focus Program on Safe Work. International Labour Organisation The Evergreen State College, Washington.

Esmaeili, B., Hallowell, M.R., 2012. Diffusion of safety innovations in the construction industry. J. Construct. Eng. Manage. 138, 955–963.

Feng, Y., 2013. Effect of safety investments on safety performance of building projects. Saf. Sci. 59, 28–45.

Feng, Y., Zhang, S., Wu, P., 2015. Factors influencing workplace costs building projects. Saf. Sci. 72, 97–104.

Fernández-Muñiz, B., Montes-Peón, J.M., Vázquez-Ordás, C.J., 2009. Relation between occupational safety management and firm performance. Saf. Sci. 47, 980–991.

Fung, I.W.H., Tam, V.W.Y., Lo, T.Y., Lu, L.L.H., 2010. Developing a Risk Assessment Model for construction safety. Int. J. Project Manage. 28, 593–600.

Gosselin, M., 2005. La gestion des coûts de la santé et de la sécurité du travail en entreprise: une recension des écrits. PISTES 7, 1–19.

Hallowell, M.R., Hinze, J.W., Baud, K.C., Wehle, A., 2013. Proactive construction safety control: measuring, monitoring, and responding to safety leading indicators. J. Construct. Eng. Manage. 139.

Hassanein, A.A.G., Hanna, R.S., 2008. Safety performance in the egyptian construction industry. J. Construct. Eng. Manage. 134, 451–455.

Heinrich, H.W., 1930. Relation of accident statistics to industrial accident prevention. Proc. Casualty Act. Soc. XVI, 170–174.

Hinze, J., Appelgate, L.L., 1991. Costs of construction injuries. J. Construct. Eng. Manage. 117, 537–550.

Hinze, J., Hallowell, M., Baud, K., 2013. Construction-safety best practices and relationships to safety performance. J. Construct. Eng. Manage. 139.

Ikpe, E., Hammon, F., Oloke, D., 2012. Cost-benefit analysis for accident prevention in construction projects. J. Construct. Eng. Manage. 138, 991–998.

Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT), 1991. NTP-273: Costes no asegurados de los accidentes: método simplificado de cálculo. INSHT, Madrid.

INSHT, 1999. NTP 540: Costes de los accidentes de trabajo: procedimiento de evaluación. INSHT, Madrid.

INSHT, 2001. Evaluación de los costes de los accidentes de trabajo y enfermedades profesionales. Centro Nacional de Condiciones de Trabajo, CNCT-INSHT, Barcelona.

INSHT, 2003. NTP 640: Indicadores para la valoración de intangibles en prevención. INSHT, Madrid.

INSHT, 2009. Encuesta Nacional de Gestión de la Seguridad y Salud en las Empresas (ENGE). INSHT, Madrid.

Instituto Navarro de Salud Laboral (INSL), 2003. Análisis de costes de accidentes de trabajo. INSL, Pamplona.

Instituto Riojano de Salud Laboral (IRSAL), 2008. Estudio del coste económico de los accidentes de trabajo registrados en la Comunidad Autónoma de La Rioja. IRSAL, Logroño.

Jallon, R., Imbeau, D., de Marcellis-Warin, N., 2011a. Development of an indirect-cost calculation model suitable for workplace use. J. Safe. Res. 42, 149–164.

Jallon, R., Imbeau, D., de Marcellis-Warin, N., 2011b. A process mapping model for calculating indirect costs of workplace accidents. J. Safe. Res. 42, 333–344.

Ku, K., Mills, T., 2010. Research needs for building information modeling for construction safety. In: Sulbaran, T., Sterling C. (Eds.), Int. Proc. Associated Schools of Construction 45th Annual Conf. University of Southern Mississippi.

Laufer, A., 1987. Construction accident cost and management safety motivation. J. Occup. Acc. 8, 295–315.

Levitt, R.E., Parker, H.W., 1976. Reducing construction accidents – top management's role. J. Construct. Div. 102, 465–478.

Manu, P., Ankrah, N., Proverbs, D., Suresh, S., 2013. Mitigating the health and safety influence of subcontracting in construction: the approach of main contractors. Int. J. Project Manage. 31, 1017–1026.

Martínez Aires, M.D., Rubio Gámez, M.C., Gibb, A., 2010. Prevention through design: the effect of European Directives on construction workplace accidents. Saf. Sci. 48, 248–258.

Miyakawa, T., Nakamura, H., Umezaki, H., 2011. Study for evaluation index of investment effectiveness for machine and manufacturing system includes protection measures. J. Mater. Adv. Res. 320, 314–318.

Montero, M.J., Araque, R.A., Rey, J.M., 2009. Occupational health and safety in the framework of corporate social responsibility. Saf. Sci. 47, 1440–1445.

Instituto Vasco de Seguridad y Salud Laborales País Vasco (OSALAN), 2005. Costes de la accidentalidad laboral en Euskadi en el año 2005. OSALAN, Baracaldo.

Oxenburgh, M., Marlow, P., 2005. The productivity assessment tool: computer-based cost benefit analysis model for the economic assessment of occupational health and safety interventions in the workplace. J. Safe. Res. 36, 209–214.

Riel, P.F., Imbeau, D., 1995. Economic justification of investments for health and safety interventions. Part I and II. Int. J. Ind. Eng. 2, 45–64.

Riel, P.F., Imbeau, D., 1996. Justifying investments in industrial ergonomics. Int. J. Ind. Ergon. 18, 349–361.

Riel, P.F., Imbeau, D., 1998. How to properly allocate the health and safety insurance cost within the firm. J. Safe. Res. 29, 25–34.

Rikhardsson, P.M., 2004. Accounting for the cost of occupational accidents. Corp. Soc. Responsib. Environ. Manag. 11, 63–70.

Rikhardsson, P., 2005. Accounting for Health and Safety costs: Review and comparison of selected methods. Business Strategy and the Environment Conference. Uiversity of Leeds, Leeds.

Rikhardsson, P., Impgaard, M., 2004. Corporate cost of occupational accidents: an activity based analysis. J. Acc. Anal. Prevent. 36, 173–182.

Simmonds, R.H., Grimaldi, J.V. (Eds.), 1963. Safety Management. Richard Irwin, Homewoood, IL.

Tappura, S., Sievänen, M., Heikkilä, J., Jussila, A., Nenonen, N., 2015. A management accounting perspective on safety. Saf. Sci. 71-B, 151–159.

Zou, P.X.W., Sunindijo, R.Y., Dainty, A.R.J., 2014. A mixed methods research design for bridging the gap between research and practice in construction safety. Saf. Sci. 70, 316–326.