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Design of a safety cost estimation parametric model in oil and gas engineering, procurement and construction contracts

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ABSTRACT

The purpose of this research is to identify parameters that govern safety costs in oil and gas projects. An initial conceptual model was proposed to identify the contractual position of safety management system in engineering, procurement and construction (EPC) projects, followed by identification of safety work packages and estimated costs per package. Next, a work breakdown structure (WBS) and cost breakdown structure (CBS), with the suggested safety parameters included for the case study project in focus. Then, a mathematical model was designed based on the parametric modeling approach and the related weighting factors were determined. The proposed model can be considered as an innovative approach to designing safety indicators in oil and gas projects. Field studies and interviews were conducted to investigate the validity of the variables based on the Delphi method. Finally, safety management costs for different phases of the project and related weighting factors were determined separately. The results indicate that the safety management's weighting factors are 1.1% of the total project's weighting factor.

1. Introduction

Nowadays, the political, social and economic activities focus on the protection of human resources, engaged in economic sectors. Experiences show that economic growth and industrial development depend on a number of factors. In addition, damages caused by workplace accidents and related direct and indirect costs show the importance of safety management system (SMS) in organizations. Furthermore, obtaining a health, safety and environmental (HSE) certificate and award of safety performance are required for being in a competitive market. Hence, over the past decades, the industrial managers' concerns have been directed towards compliance with safety rules and standards.

For this reason, Battaglia et al. (2015) believed that investment in occupational health and safety (OHS) plays a vital role for economic return. Moreover, most companies have found that investments in OHS sectors significantly lead to improvement in production and financial performance (Huang et al., 2007, 2011). Hereby, it is important to point out that in many projects, safety budget is not separately defined; and its related costs are paid from the project budget, which causes the execution of the SMS to encounter problems.

Ale et al. (2015) referred to lack of a separate budget for the safety sector and believed that the SMS implementation costs are paid from the project budget. This means, if the project budget is not enough, the SMS development and improvement in the projects is impossible to take effect. Therefore, it seems that the investment in safety depends on the country's safety culture, in which the company is established, and the country's development level and their national regulations when it comes to uncertain safety costs in any contract. In the current study, a cost calculation model was designed to estimate the safety budget of projects and develop an integrated structure for customer payments and its expenditure by the oil and gas contractors. Based on this, the safety cost prediction in engineering, procurement and construction (EPC) projects will help management in the strategic decision-making process and its operational programs.

The present study aims to design a proper safety management model by finding suitable and efficient safety parameters to assist in the cost estimation during the execution of oil and gas EPC contracts. Finally, these questions are going to be answered: “Which safety management parameters are required to be incorporated into EPC contracts?”, “How are these costs estimated?”, and “How can safety parameters be incorporated into project invoices and get a progress report?”

2. Literature review

Despite the serious needs for SMS, most organizations have not put it in their priority programs due to many reasons such as lack of knowledge, necessary skills or incentive, or lack of human resources.

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Haslam et al. (2016) announced that some managers look at safety programs as bureaucracy and some others as additional costs. Based on Tompa et al. (2009), the efficient management of safety brings about a decrease in occupational accidents, injuries and illnesses and an increase in organizational profitability, but managers still do not understand these benefits. Some researchers argue that a mere investment in this sector will not result in the improvement of the SMS; Other issues such as improvement in communication and more accurate planning, as well as consideration of experts approach can improve safety performance (Grant et al., 2003; Rikhardsson, 2005). However, according to Marson (2002), occupational accidents and injuries can bring about extra costs to organizations.

Studies show that management commitment is a key factor in the success of safety programs (Abudayyeh et al., 2006; Aksorn and Hadikusumo, 2008; Haupt, 2003; Langford et al., 2000). In this regard, Sunindijo and Zou (2012) believe that the implementation of SMS in organizations will not be successful without management commitment and promotion safety culture. Teo et al. (2005) believe that 75% of fatal accidents in construction industry in England are due to inefficient management. According to Michael et al. (2005), the management focus to safety will lead to improve company's safety performance and achieve positive outcomes. Rechenthin (2004) argues that accident occurrence is directly a result of weakness in management support system. O'Toole (2002) has pointed to the role of continuous management support in the successful implementation of security programs in organizations.

This is while other researchers have focused on the role of other employees in the success of the safety performance. Dastous et al. (2008) believe that efficient risk management does not only require development of different techniques, but also requires a change in the work execution process and consideration of the role of human. Langford et al. (2000) believe that better safety performance requires the involvement of all personnel levels in safety responsibilities.

Also according to Cagno et al. (2013), managers generally consider safety as an extra cost while they do not take into account the real benefits of a difference in safe and unsafe activities. Calculation of accident costs is one of the main challenges of many companies. It is while, based on Haslam et al. (2016) studies, most companies have been able to estimate the costs of accidents, but systematically have not calculated the costs of implementing safety management system. In this regard, many companies do not even calculate the costs resulted from their unsafe actions.

Rechenthin (2004) believes that safety costs in industries are remarkable; to understand the real costs of safety, it is necessary to calculate the costs of accidents that have not happened yet; which is impossible. He also calculated the cost of work injuries and fatalities in all different industries. In addition, Rechenthin (2004) mentioned the competitive value of implementing safety principles within the organization as well as the employer. He used the SWOT model to examine the role of organization's safety plans in the competition.

Feng et al. (2014) believe that the cost of safety varies according to the geographic location and type of industry. In this regard, Sousa et al. (2015) have calculated and compared safety costs in the UK and USA. Based on their studies, the cost of non-implementation of the HSE management system in the UK is estimated about 2.6% of the total GDP, while it is about 3% in the USA. Also, the cost of occupational accidents and illnesses in Norway was calculated as 6% of GDP in 1990.

Cagno et al. (2013) investigated and modeled the OHS costs to analyze the economic impact of safety issues. They also studied the effects of risk reduction on the change of costs. However, their cost calculation method, the type of studied industry and the involved parameters were not specified.

Finally, the safety budget in many projects is not defined separately, and its related costs are paid from project budget; conclusively, the implementation of the project SMS usually will face many problems. Ale et al. (2015) have stated that no separate budget for project safety costs is defined and the project safety costs will be paid from the overall project budget. Therefore, if the project budget is not enough, SMS development and improvement may be practically impossible.

2.1. Classification of safety costs

Several studies have been carried out on project cost prediction and the relationship between cost and execution time in projects (Ahn et al., 2014; Brotons Martinez and Sansalvador Selles, 2015; Gu et al., 2011; Kaiser and Liu, 2014; Mirdamadi et al., 2013; Qian and Ben-Arieh, 2008; Parthan et al., 2012). The differences between direct and indirect costs were described in different evaluation techniques. Some papers also have presented the safety costs such as cost of accidents, training and safety climate (Tappura et al., 2014; Zou and Sunindijo, 2013), while others have evaluated the cost-benefit of safety investments and achieved profits (Aven and Flage, 2009). In this regard, Tappura et al. (2014) has studied the use of the Management Accounting (MA) approach in safety issues and claimed that this method could be extremely useful in calculating the cost of safety, safety performance and its profit; they believed that this method assists in safety-related decision-making. According to Tappura et al. (2014), safety costs consist of the costs per injury or the total cost of accidents; they also declared that to calculate the cost of investing in the safety sector, the efficiency of the improvements should also be considered. In this category, the saved costs due to the implementation of SMS were calculated, while there is also a need to calculate the costs of required safety equipment (Tappura et al., 2014). Tappura et al. (2014) believed that the total cost of SMS should be determined so that it can be used for managers as an incentive scheme to consider safety issues in decision-making.

Corcoran (2002a) looked at the safety principals as an iceberg believing that most of this iceberg is not visible under the water. In his opinion, consideration should be given to the costs of losing the competitive market and the organization's credibility, in addition to the costs of damage to equipment, personnel replacement, administrative costs and costs in the event of a delay in restarting operations.

In the following, different approaches for classifying safety costs are investigated. Rikhardsson (2005) compared four following methods to measure safety costs: (A) Accident Consequence Tree; (B) Reie and Imbeau ABC; (C) Systematic Accident Cost Analysis; and (D) Health and Safety Executive. The results indicated that these methods have focused on the cost of occupational accidents; also, the cost estimation method used in all of these methods has been based on activity-based costing. In the simplest classification, López-Alonso et al. (2013) divided these costs into two categories: (A) Preventive costs, and (B) Costs of consequences. Lahiri et al. (2005) has outlined four categories in its net cost model: (A) The direct cost of investment in interventions; (B) Medical care costs; (C) Loss in productivity; and (D) Productivity enhancement. Tappura et al. (2014) divided the Cost of Consequences into two categories as insurable costs and non-insurable costs. Gavious et al. (2009) nominated non-insurable costs as indirect costs. Moreover, other classifications have also divided the safety costs into direct and indirect costs (Cagno et al., 2013; Gavious et al., 2009; Tappura et al., 2014). In this regard, Tappura et al. (2014) and Gavious et al. (2009) consider indirect costs more significant. Sun et al. (2006) have divided the safety indirect costs into five categories: (A) Legal and Administrative; (B) Productivity; (C) Replacement; (D) Investigation; and (E) other costs. Gavious et al. (2009) have discussed Marginal Costs as non-measurable costs such as credit or incentive costs alongside direct and indirect costs. Brody et al. (1990) have covered OHS costs, including OHS costs, preventive costs, and accident costs. Sousa et al. (2015) presented a new classification of OHS costs according to Pelaez (2008), including: (A) According to imputation (direct costs and indirect costs); (B) According to the nature (costs of materials, services, personnel, depreciation, opportunity, etc.); (C) According to the activity level (fixed costs and variable costs).

Generally, researchers believe that it is easy to identify direct and