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Investigating the effectiveness of safety costs on productivity and quality enhancement by means of a quantitative approach

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ABSTRACT

Senior managers face a number of challenges in safety area, e.g., to what extent it should be invested in safety programs. This study aims at determining the effectiveness of safety cost factors in productivity, quality, and safety performance in steel industry. The data related to five steel companies were gathered from documents of the companies. These data pertained to five safety cost indicators and eight indices relating to safety performance, productivity, and quality. Data envelopment analysis (DEA) approach was used to compute the influence of safety costs and to analyze the obtained results. The results of DEA demonstrated that safety cost indicators would positively affect the performance of decision-making units (DMUs) in this study. Furthermore, the results regarding sensitivity analysis indicates that Capita Total Safety Costs (CTSC) plays a considerable role in the enhancement of productivity and quality in this particular case study. To the best of the researchers' knowledge, this is the first study that evaluates the influence of safety cost indicators on productivity, quality, and safety performance through a quantitative method in steel industry. Therefore, it can assist managers and stockholders invest purposefully in safety and health programs to reduce interruptions and increase productivity.

1. Introduction

Nowadays, work accidents lead to the imposition of huge costs on companies and employers, and these costs, in turn, affect safety performance (Abad et al., 2013). Hence, safety programs can play a vital role in developing companies (Gopang, 2017); on the other hand, a large number of companies are unable or unwilling to control such costs (Brody et al., 1990). In such conditions, managers always encounter challenges in safety areas; for instance, to what extent they should spend on safety programs. Do the costs meet their benefits or not? A lack of strong belief in safety or possession of wrong beliefs in this area, caused by the ignorance of the cost-benefit implementation of safety programs, can undermine the implementation of safety programs. Considering such points as productivity definition; the optimal usage of material resources, human resources, and scientific facilities; the decline of production costs, market development, and the increase of the employment rate, efforts for dominating real wages and life standards in a manner that it can be useful to the worker, manager, and general consumers, it can be expected that the provision of safer and healthier workplaces can increase labor productivity and job satisfaction (Boles et al., 2004; de Greef et al., 2004; Lamm et al., 2007). Thus, the benefits of investment in occupational safety may lead to cost saving, a decrease in the number of accidents, fewer interruptions in production, and increased productivity (Zou et al., 2010). In fact, there is a relationship between job accidents and productivity (Bayram et al., 2017), i.e., the greater the number of the accidents, the higher costs it would impose on various sectors (Hola, 2007). In this line, safety programs play an important role in industry, worker productivity, and product quality (Shikdar and Sawaqed, 2003; Omidvari et al., 2015).

Previous studies have shown that the implementation of safety programs is one of the most influential factors in the productivity growth (Andreoni, 1986; Larsson and Betts, 1996; Dembe, 2001; Robson et al., 2007; Frick, 2011; Bianchini et al., 2017). In this context, statistics have revealed that investment in occupational safety and health and cost prevention presents a profit of approximately 1:1–1:10 in return (Falkner et al., 2012; Shalini, 2009). The European Agency for Safety and Health at Work categorized investment in health and safety into two subgroups, i.e. direct and indirect. Direct benefits include reduced insurance premiums, reduced sick pay costs, improved production/ productivity rates, reduced product and material damages, lower accident costs, and production delays. From among indirect benefits, one can refer to reduced absenteeism, reduced number of the personnel,

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improved corporate image, improved chances of winning contracts, and improved job satisfaction, and morale. This finding clearly shows that occupational safety and health prevention costs do have a positive influence on safety performance, accident cost savings, and worker productivity (Bayram et al., 2017; Gervais et al., 2009). However, the aim of this study is to determine the influence of safety costs on productivity and quality. To this end, a powerful quantitative tool, namely data envelopment analysis (DEA) is used to calculate the efficiencies and analyze them (Azadeh et al., 2017a).

2. Literature review

The review of the related literature has shown that a large number of studies have been conducted so far on occupational safety and health costs (e.g., safety cost, prevention cost, and accident cost); however, to the best of our knowledge, few studies have been conducted on the effectiveness of safety costs on productivity and quality by means of quantitative approaches. In fact, it is to be known whether or not safety costs are beneficial and effective for companies. In this domain, Oxenburgh and Marlow (2005) introduced a productivity assessment tool to analyze costs and their impact on occupational health and safety in a manufacturing workplace. The data of the study were related to employees and workplace including the number of employees, their working times and wages, recruitment, insurance, and energy use. The results of the study showed that using such a tool makes it possible to estimate the safety costs effectiveness of workplace change before its introduction. Maudgalya et al. (2008) found out that although safety, as a business objective, can help an organization obtain the long-term benefit of operational sustainability, the conduct of further studies is required to demonstrate conclusively the exact impact of safety investment on the increase of productivity and quality. The data related to 18 case studies were collected and analyzed to determine the influence of safety investment on productivity and quality. In general, the findings of the study revealed an increase of 66% in productivity and 44% in quality. In addition, Bayram et al. (2016) concluded that occupational safety has a relationship with health costs, safety performance, employee satisfaction, and accident costs. They gathered the required data from 159 OHS management system18001 certified firms in Turkey. The data were analyzed through structural equation modeling. Moreover, the results indicate that safety performance and employee satisfaction can increase labor productivity and decrease accidents in an organization.

Bianchini et al. (2014) stated that investment in safety and health for the purpose of prevention is an acceptable example of using organizations' resources in comparison with usual investments in production. In the study, real data including two commercial companies of 14 and 70 employees and two public utilities of approximately 1000 and 2000 employees were used. The results showed that the investment reduces injuries and accident rates and, thereby, provides benefits for the community not only for the enterprise. Hence, it should be supported by government. Of course, Feng (2013) believed that safety investment will not have a positive effect on accident prevention if the hazard level and safety culture level of the project are low. The inference was based on collected data from building projects through interview, questionnaire, and archival data. However, as Bayram et al. (2016) has pointed out, these investments should not be considered as a financial burden, but rather they improve the profitability of a business by reducing the costs resulting from accidents. Finally, Bianchini et al. (2017) presented an efficacy index to purposefully quantify an Occupational Health and Safety Management System (OHSMS). The data used in the study were associated with the National Institute for Insurance against Accidents at Work which is known as INAIL database. The findings showed that preventive safety investments are likely to be positive for the health and safety programs pertaining to workers in workplaces. The study was conducted in small-medium enterprises.

Table 1 presents different related studies in which different factors and approaches have been used. The mentioned studies and their attributes are also comparable by the table. According to the table, this is the first study that evaluates the influence of safety costs on productivity and quality indicators through DEA technique in steel industry.

3. Method

3.1. Research strategies and sample

This study was conducted with the aim of determining the effectiveness of safety costs in a set of safety performance indicators, productivity, and quality in five steel companies working on steel and the related products. The main reason for the selection of these companies was that they had been annually experiencing severe accidents, which were even fatal sometimes. The companies were selected based on random effect and their interest in participating in this study. Since the selected companies have no integrated database system with common factors; therefore, the costs were categorized in two main groups, including labor safety costs and total safety costs. Productivity indicators also included labor productivity, labor competitiveness, total productivity factor, quality index, and production rates. The required data were collected using the documents and archives of safety, accounting, and production units of the companies. Costs, numbers and figures of the variables were expressed in the form of per capita and percentage based on the conditions to make the data comparable. This study is an attempt to evaluate these companies in steel industry using five safety cost factors and eight indicators related to safety performance, productivity, and quality by DEA approach.

3.2. Measures

Previous studies have examined safety costs, prevention costs, and accident costs (Bayram et al., 2017). In addition, some studies have investigated the combined effects of safety investment, safety culture, and project hazard on safety performance (Feng, 2013). However, it seems that no study has been conducted to investigate the costs spent on safety and health fields and their effectiveness in productivity and quality by means of a quantitative approach. Therefore, it is one of the first studies that evaluates and determines the effect of safety costs on quality and productivity in steel industry through a quantitative approach based on DEA method. Hence, there is a clear need for defining the parameters and indicators for this purpose. Based on the aim of this study, parameters and indicators are classified in two subgroups. The schematic structure of this study is shown in Fig. 1. In fact, the figure comprises the schematic view of the different steps of this study.

3.2.1. Safety cost factors

Due to the lack of access to sufficient information on the expenses paid for all types of activities, such as staffing, compulsory training, safety equipment and facilities, etc., five factors were selected in the study wherein labor safety costs and total safety costs were considered. Thus, safety cost factors are the sum of the following components:

- Capita Labor Safety Costs (CLSC): The CLSC is determined through division of the cost of safety personnel by the total number of company personnel per year. The ratio indicates that how much companies allocate to safety costs for any worker. The CLSC was calculated only for the company employees while the contractors were excluded in this study.
- Capita Total Safety Costs (CTSC): The CTSC is measured by dividing the total cost of safety by the number of workers per year. This ratio indicates the amount of money companies pay to each worker for safety.
- Percentage Safety Labor Costs to Total Costs (PSLCTC): The PSLCTC is measured by dividing the safety personnel costs by the total cost