Economic Assessment of Industrial Accidents Caused by Abnormal Behaviors

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Abstract. The economic assessment of industrial accidents caused by abnormal behaviors can not only improve the risk assessment results but also serve as a crucial criterion for prioritizing the correction plans. Three stages of works are designed to derive the loss figures from assessing the standard operation procedure. The objective of stage one is to identify potential abnormal behaviors through analysis of activities. The objective of stage 2 is to identify cost types initiated by different accident losses. The objective of stage 3 is to establish the accident cost bank through analyzing the historical accident data. Two industrial cases, including one semiconductor and one steel company, were studies to demonstrate the feasibility of this approach in both high-tech and traditional industry. This study proposes a framework to develop abnormal behavior identification and cost estimation model.

Keywords: abnormal behaviors, risk assessment, safety economics.

1 Introduction

Abnormal behaviors, defined as deviations from standard operation procedures, can create not only the quality problems, but also the interruption of production activities. Empirical studies have shown that abnormal behaviors are one of the major causes for industrial accidents. Although, industry tries to implement the safety observation and training programs to limit the probabilities and magnitudes of the abnormal behaviors, these types of unexpected acts continuously occur and create threats for line managers to maintain stable daily operations. As a result, operators and managers must constantly monitor abnormal behaviors and perform corresponding measurements based on the risk assessment results. This continuous process can easily be forgot or ignored by line managers if the economic assessment data were not properly provided. Moreover, the economic assessment data can not only improve the risk awareness of line managers but also serve as a crucial criterion for prioritizing the correction plans.

The economic assessment data can be derived from loss figures of past accidents. Unfortunately, these figures are currently not directly available due to the lack of collection mechanism and historical data. Different approaches are adopted by

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industry or insurance company to collect the loss figures. These approaches focus mainly on the estimation of total losses. However, they provide little information for identifying the causes. Often the accident investigation techniques are needed. The relationships between losses and abnormal behaviors are not established. It is likely for managers and operators to ignore the importance of controlling the abnormal behaviors. This study tries to develop an approach to assess industrial accidents economically, thus increasing the awareness of controlling abnormal behaviors.

2 Background Information

Various losses estimation methods are developed to help industry to assess the economic impacts of accidents. One approach calculates the total losses through estimating the direct cost and indirect cost. But the scopes of direct costs and indirect costs have not been formally established or accepted by practitioners or researchers. The loss figures calculated through this type of estimation approach are too rough to represent the cost of accidents. To solve this problem, industry use insured and uninsured costs to estimate the loss. The insured costs are easy to obtain. But the uninsured costs, which usually are the major loss of accidents, are hard to find.

Another approach is developing the cost typology. Various costs classification schemes were developed to calculate the costs of ergonomics solutions or safety and health accidents. Riel and Imbeau (1996) proposed a cost typology which comprises three different categories: insurance-related costs, work-related costs, and perturbation costs [1]. Each of these categories is further subdivided into cost components which can be used to develop detail safety and health cost typology. In recent year, there are increasing concerns on how to measure these costs. Unfortunately, there are still no agreements on how and what to measure yet. Different distinctions, such as economic vs. non-economic costs, fixed vs. variable costs, direct vs. indirect costs, and internal vs. external costs, were proposed to identify which costs can financially motivate the industrial managers to improve their working conditions. Dorman (2000) believed that, based on economic theory, industrial managers are more likely concerning of the economic, variable, direct, and internal costs [2].

The scope of cost estimation and the level of study play key factors in selecting cost typology. Cost estimation performed at the company level is primarily used by managers to assess the needs of implementing accident control measurements. Therefore, the scope of cost estimation and typology should satisfy the needs of industrial managers.

Literature reviews indicate that there are abundant of scientific literatures in studying safety and health and ergonomics costs. Anderson (1992) developed guidelines of economic evaluation of ergonomic solutions for practitioner, where the Net Present Value (NPV), Internal Rate or Return (IRR), Annuity Method (AM), and the Payback Period Method (PPM) were illustrated to examine the profitability of ergonomic solutions [3]. Alexander (1994) classified seventeen justification techniques of funds for ergonomics, safety and health into seven strategies [4].

The fundamental requirement of these approaches is that the accounting system can provide the necessary information. Unfortunately, no accounting model specially

tailored to ergonomics has been designed [1], [5]. The information about different costs and their origins are not provided. As a result, incomplete cost information can not be used as a decision base for management and control purpose.

In order to solve the complex cost allocation and tracking problems, the Activity based costing (ABC) approach is introduced to measuring ergonomics, safety and health costs. In an ABC calculation, all manufacturing activities are specified, and the corresponding costs are estimated. These activities are grouped according to their background and connected to the product through cost drives that form an allocation basis for the different groups of activities. The cost drive is a measurable unit forming a link between activities and products. Riel and Imbeau combined the ABC and the hidden cost approaches to analyze the behavior of quantifiable and irreducible components of health and safety costs. The ABC provides a unifying framework for all quantifiable costs and the hidden cost approach is adopted to estimate irreducible costs.

Most studies of ergonomic, safety and health costs focus on the economic justification of project improvements or investments. The exception is that Dahlen and Wernersson (1995) tried to visualize the human factors, such as absenteeism and labor turnover, as costs in an accounting system. Only a few studies of costs modeling aim at the economic evaluation of impacts caused by human errors.

Previous discussions indicate that traditional accounting system can not directly provide loss information for assessing the impacts of accidents. This obstacles force industrial managers justify the proper accident and injury prevention process through experiences. As a result, the efficiency and effectiveness of the system safety barriers are in doubt and the smooth operation of manufacturing activities are insecure.

3 Methodology

To economic assess industrial accidents caused by abnormal behaviors; three important issues have to be considered. The first issue is how to identify abnormal behavior? In this study, abnormal behavior is defined as the deviations from normal operation. The abnormal behavior can be identified through safety observations. The standard operation procedure is used as the criteria to identify abnormal behaviors. Human Error Assessment System for manufacturing working environment has been developed through the combination of human errors diagnostic (HED) and human errors criticality analysis (HECA) methods. This system can help industry to develop its own human errors assessment model based on evaluation of daily plant operations. This system provides the decision-makers with the capability to assess the critical human errors and their impacts in manufacturing environment so that accidents can be avoided. The types of accident losses caused by each abnormal behavior are identified and its corresponding possibilities and magnitudes data are estimated by groups of senior workers including safety and health personnel and managers.

The second issue is to identify cost types initiated by different accident losses. At first, the cost typologies are summarized through reviewing related research works. The definitions and classifications of cost types are given by groups of safety experts, including safety and health practitioners based on industrial customs. These cost

types are explained to factory managers and supervisors before they perform the criticality analysis of their contributions to each loss type through the Analytic Hierarchy Process (AHP). The Expert Choice software is used to conduct the pair-comparison between each cost type and identify the critical cost types for each type of accident.

The third issue is to establish the accident cost bank through analyzing the historical accident data. Group of managers and supervisors were asked to estimate the loss of every critical cost type for each accident after reviewing corresponding record and related information. These numbers were averaged to form the basic loss figures for each type of accident. To economically assess the accidents caused by abnormal behaviors the assessor first observing the operator and record the abnormal behaviors through work sampling schedule. Then the corresponding losses are look up from the accident cost bank and summation.

4 Discussions

Two industrial cases, including one semiconductor and one steel company, were studies to demonstrate the feasibility of this approach in both high-tech and traditional industry. To establish the accident cost bank for the semiconductor company, totally four thousands two hundred and sixteen accident cases were studied. Five hundred and four accident cases for local steel company were studied. These accidents were grouped into similar categories and the corresponding critical cost types were identified and respective costs are estimated based on the judgments of safety and health personnel.

In order to help the industrial manager to justify how to properly allocate limited company resources to change or maintain the current operation status, the mechanism of estimating the losses of abnormal behavior is required. Historical data usually can not provide enough information for managers to estimate the costs. Therefore, further refinery works are needed. Future works will focus on analyzing more accident cases and improve the reliability of cost bank.

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