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An Overview of Cost-benefit Models/Tools for Investigating Occupational Accidents

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The safety-related economic (cost-benefit and cost-effectiveness) tools and models discussed in this paper allow the user to execute an investment analysis, in order to evaluate investments in preventive measures related to occupational accidents. The available software shows that there are a multitude of indirect consequences of occupational accidents next to the direct consequences that should be taken into account to calculate their costs and benefits. Furthermore, during the study we noticed that available cost-benefit tools clearly focus on occupational accidents instead of major accidents.

1. Introduction

Companies operating in the energy, petroleum, or more general, in the process industry, face many occupational risks. These occupational risks can be classified into the following three categories:

- (i) Very large occupational risks with an outcome so unacceptable for the company that these risks need to be reduced right away;
- (ii) Very small occupational risks where no further investments in risk reduction are necessary;
- (iii) Occupational risks that fall between the previous two risk categories.

The third category occupational risks have to be reduced to the lowest level practicable, bearing in mind the benefits of further risk reduction and taking into account the costs of that risk reduction. Thus risks in this category must be reduced to a level that is As Low As Reasonably Practicable (ALARP) or As Low As Reasonably Achievable (ALARA). Thus, a company has two choices when the occupational risk is located in the third region: either take further risk reduction measures or show that additional risk reduction is not reasonably practicable. “Not reasonably practicable” indicates that the costs are higher than the accompanying benefits (Rushton, 2006).
In general, literature indicates that company management often has difficulties with the decision-making process for investing in safety policies and the prevention or mitigation of accidents (Gavious et al., 2009). Overall, in organizations there is a general lack of knowledge of costs related to accidents. Because of this lack of understanding most of the costs related to an accident are believed to be insured and thus are often believed not to play a part in the financial situation of the company. In addition, costs are assumed to be limited to the direct accident costs, although indirect accident costs also need to be included. Therefore it is widely accepted that there is not a valid reason to spend significant capital and time in the complex decision-making process of investing in safety (Gavious et al., 2009).
Another reason why companies tend to not be able to see the importance of a transparent and extensive decision-making process of investments in safety is the measurement difficulty of costs and benefits (Gavious et al., 2009). An accurate calculation of many of the required data in the cost-benefit analysis is a complex and highly time-consuming process (Paltrinieri et al., 2012). Therefore this article aims to provide

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an overview of tools allowing to execute a cost-benefit analysis for prevention purposes. Nevertheless, managers will need to apply the proper managerial actions for any cost-benefit analysis to be effectively implemented in a company, as employees will possibly not have the right skills in first instance to use a cost-benefit tool, will refuse to put much effort in the process, or just use previous outdated process safety studies' data made by colleagues (Paltrinieri et al., 2012). To counter these possible hurdles for safety cost-benefit tool implementation, the acquisition of new skills or the adaptation of working patterns and employee behaviour can be supported by an adjusted compensation program for the employees. In fact, companies should think of rewarding the people who learn how to work with safety-related cost-benefit tools and who actually implement it in their work pattern of the decision-making process through a 'pay for performance' system (Henderickx et al., 2010).

Moreover, the common assumption of many of today's managers is that accident costs are inevitable and thus represent sunk costs. In turn, they may consider investments in safety and accident prevention merely as marketing or reputation expenses, to enhance the company's, or their own, image. Therefore there will not be time and money for an extensive decision-making process of investments in prevention measures. This perception and approach is clearly wrong, as a company should take all the benefits of prevention of accidents into account, such as organizational and legal benefits (Gavious et al., 2009).

An important reason why companies should consider executing economic analyses for the evaluation of investment decisions to prevent occupational accidents is that the results can assist employees to convince managers of the importance of safety measures from an economic point of view. In addition, a safety cost-benefit- or cost-effectiveness analysis can aid managers in the efficient safety budget allocation, as some safety measures may turn out to be more efficient compared to others (Gavious et al., 2009).

An economic point of view is vitally important, as a company has to take its shareholders into account (besides other stakeholders), who desire a high profit margin above all else. In addition it should be stressed that the outcome of any safety-related economic analysis is not meant as a final investment decision, but merely to assist the decision-maker in the prevention investment decision process. In fact, a decision-maker is recommended to use a cost-benefit tool with caution, as the data is subject to varying levels of quality, detail and uncertainty (Roelen et al., 2000).

In summary, in order to cope with occupational risks, which are present in every organization, companies spend part of their budgets on safety and risk reduction measures. As budgets are not infinite, companies will have to make a choice regarding the projects and prevention measures they implement. Therefore, it is important to allocate safety and prevention budgets in a cost-efficient way. A cost-benefit analysis of the possible prevention measures will contribute to this optimal allocation, as the company will only be advised to invest in projects where benefits exceed the costs. The "costs" in case of such cost-benefit analyses are composed of all the costs related to the implementation of a risk reduction measure. The 'benefits' of such cost-benefit analyses may for example be represented by the avoided occupational accident costs, which are the difference between hypothetical accident costs before and after the implementation of the preventive measure (Reniers and Sörensen, 2013).

2. Accident typology

It is important to note that different types of accidents can be defined. The different kinds of possible accidents can be categorized into three types based upon the amount of information available:

Type I accidents are characterized by the availability of a lot of historical data, and can thus be predicted fairly accurate using commonly known statistical methods and tools. These accidents are on average labelled as work-related accidents or occupational accidents, such as small injuries due to falling or minor material damage (Reniers and Sörensen, 2013). This article discusses cost-benefit tools available for addressing this type of accidents.

Type II accidents represent accidents where historical data is not widely available, making it hard to predict them. In contrast to type I accidents, common statistical analyses cannot easily be used and the results of analyses regarding these accidents should be handled with great care. These accidents are regarded as major accidents with a lot of property and business interruption damage, and often have multiple fatalities. Examples of type II accidents are explosions, very large fires, significant releases, toxic clouds, etc.

For Type III accidents there is no historical data available. This type of accidents is regarded as impossible to predict, since such an accident has never happened before. Type III man-made disasters are also called "black swan accidents".

3. Existing models

The safety-related cost-benefit tools discussed in literature are focused on occupational accidents instead of major accidents and their scope is rather limited. Table 1 provides a non-exhaustive list of existing occupational accident tools and models.

Table 1: Economic assessment models for occupational accidents

Model or Tool	Type	Function	User-friendliness	Country/ Agency
AKK v2.0 (Rzepecki, 2002)	Software	To calculate a cost-benefit analysis.	Not stated.	Poland
PN-N-18004:2001 (Polish Standards Committee, 2001)	Paper & Pencil	A model for cost-benefit analysis at a company level, accounting for all the important OSH items including the premium costs for accident insurance, costs for accidents at work, occupational diseases, absence from work, overtime due to improper work conditions, benefits paid to employees, and prevention.	Not stated.	Poland
TYTA model (European Commission, 2004)	Software	A calculation tool that estimates the economic impact of the working environment at company level.	Not stated.	Finland
Economic Assessment Tool (Niven, 2000)	Spread-sheet	A model combining cost effectiveness analysis and option appraisal.	Straight-forward to use	United Kingdom
Costs Calculator (HSE, 2005)	Software	A tool to understand the costs involved in accidents, injuries, incidents, and ill health	Straight-forward to use	United Kingdom
Productivity Assessment Tool (Oxenburgh & Marlow, 2005)	Software	Economic assessment of occupational health and safety interventions in the workplace. Aim: establishing the effectiveness of an intervention prior to its introduction, based on a cost-benefits analysis.	Straight-forward to use	Australia
The ORC Return on Health, Safety and Environmental Investments (ROHSEI) (Linhard, 2005)	Software	Provides a comprehensive look at health, safety or environmental investment projects and their potential financial impacts.	Used by more than 200 companies.	United States
Value Principle (Marson, 2001)	Paper & Pencil	A method to establish the appropriate position of occupational health in corporate thinking. The method uses four steps: strategic planning, issues development, option establishment, plan implementation.	Not stated.	United Kingdom
The Potential (Bergström, 2005)	Software	A tool incorporating different changes in working conditions (between 12 to 300 variables are employed) to carry out an economic analysis.	Not stated.	Finland
Tool Kit (Amador-Rodezno, 2005)	Software	The tool facilitates (i) risk assessments, (ii) making cause-effect relationships, (iii) improving decisions on OSH interventions, (iv) calculations of direct and indirect costs, and (v) calculations of the overall cost-benefit of OSH interventions	Used by more than 700 companies	Central America
Health and Work Performance	Question-naire	A model to estimate the indirect costs of illness, and to obtain information on	Straight-forward to	World Health

Questionnaire (HPQ) (Kessler et al., 2004)		workplace health and productivity. Uses e.g. info on sickness absence, presenteeism, critical incidents, etc.	use (10 min. to complete)	Organisa-tion
$afety Pays (OHSA, 2013)	Web-based	A model that calculates the impact of occupational accidents and illnesses on a company's profitability.	Straight-forward to use.	United States
Prevention Matrix (Prevent, 2011)	Paper & Pencil	The model develops a cost matrix based on so-called cost categories and cost carriers, to have a clear overview of a company's accident costs.	Straight-forward to use	Belgium
SZW (Ale, 2013)	Software	A model constructing an activity profile for employee categories, comparing this with preventive measures, to determine the most cost-effective approach to lower the risk.	Not stated.	The Nether-lands
CEOccAcc (Vankerckhoven, 2008)	Software	A tool to carry out an economic investment analysis in prevention measures related to occupational accidents.	Straight-forward to use	Belgium

Source: based on Gervais et al., 2009 and Brijs, 2013

The models from Table 1 all assist in estimating the direct and indirect costs of occupational accidents. These models have in common that they all direct a great importance to indirect costs, as they often largely exceed the direct costs (Vankerckhoven, 2008). We also briefly discuss some available models/tools in the next subsections to provide an understanding of their features and purposes. The briefly discussed models/tools are the following:

- Model of the OSHA, U.S. Department of Labor: "$afety Pays"
- Prevention Matrix Model
- Tyta Model
- SZW Model
- CEOccAcc Model

3.1 Model of OSHA, US Department of Labor: "$afety Pays"

The US Department of Labor provides a web-based tool for employers, in order to assess the impact of occupational injuries and illnesses on their profitability. This tool is called "$afety Pays". It takes a company's profit margin, the average costs of an injury, and an indirect cost multiplier into account, and it generates the equivalent amount of sales a company would need to have in order to cover the occupational accident costs. This tool merely highlights how occupational injuries and illnesses can impact a company's profitability, does not allow executing cost-benefit analyses or cost-effectiveness analyses, and is not valid for major accidents (OSHA, 2013).

3.2 Prevention matrix model

This Belgian model is called the 'PreventMatrix' model, and it makes use of cost categories and cost carriers. The cost categories are identified through the categories of the bookkeeping system of organizations, and are the following: products, services, personnel, and depreciation. The cost carriers are identified according to the 'MUOPO' model, which is based on the following cost carriers: Human, Equipment, Environment, Product, and Organization. Through these classifications a matrix can be constructed, in which every cost can be assigned to a cost carrier and a cost category. The total cost of occupational accidents is the sum of the costs of every cost category for each cost carrier (Prevent, 2011).

3.3 Tyta model

The TYTA model for occupational accidents developed in Finland allows the user to evaluate the negative economic effects related to the working environment. The TYTA model generates information regarding the costs caused by absenteeism due to illness, minor accidents, personnel turnover, and alterations in working conditions. The TYTA model is not applicable for major accidents (European Agency for Safety and Health at Work, 1999).

3.4 SZW model

This model is developed by the ministry of social affairs and employment of the Netherlands, to reduce occupational accidents and absenteeism in a cost-efficient way, by determining the risk of injury during work and comparing this risk to the costs of safety measures to reduce this risk. To identify the risk that a certain category of employees face, this model sums up all the risks belonging to the category's daily activities. Thus an activity profile is constructed for every employee category, and this activity profile with its accompanying risk is compared with the cost of several safety measures, in order to reduce the risk in the most cost-efficient way possible (Ale, 2013).

3.5 CEOccAcc model

The general idea behind the CEOccAcc model (developed in Belgium) allows the user to calculate the cost of an occupational accident scenario, by taking the consequences on different parts of the organization into account. The consequence categories that are taken into account are the following: man, equipment and machines, internal work environment, material, organization, product, customer, supplier, external environment, and other consequences. After the costs of the occupational accident scenario are calculated, this model allows calculating the payback period and the costs saved, given a specified investment in safety. In addition, an indication is provided of the level of sales needed to compensate the loss due to the occurrence of the occupational accident (Vankerckhoven, 2008).

4. Conclusions

A variety of tools and models are available to carry out prevention- and precaution-related cost-benefit analyses and cost-effectiveness analyses for avoiding occupational accidents. A wide variety of parameters necessary to calculate both the costs of the considered preventive measures and the benefits related with the avoidance of accidents are used by investment decision-aid tools and models. This paper gives an overview of available safety-related models/tools and includes a list of such models/tools, as well as provides a brief discussion of some of them, based on literature. It is obvious that the potential user of a prevention-investment tool first needs to make the right choice of model or tools for his/her problem or investment question at hand, before actual implementation of the tool or model.

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