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Safety, Reliability and Risk Analysis:
Beyond the Horizon



Economic analysis of occupational risk prevention: A case study in a textile company

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ABSTRACT: Work accidents affect business and society as a whole. Fewer accidents mean fewer sick leaves, which results in lower costs and less disruption in the production process, with clear advantages for the employer. But workers and their households bear also a significant burden following a work accident, only partially compensated by insurance systems. Furthermore, the consequences of work accidents to the State and Society need also to be considered. When an organization performs an integrated risk analysis in evaluating its Occupational Health and Safety Management System, several steps are suggested to address the identified risk situations. Namely, to avoid risks, a series of preventive measures are identified. The organization should make a detailed analysis of the monetary impact (positive or negative) for the organization of each of the measures considered. Particularly, it is also important to consider the impact of each measure on society, involving an adequate economic cost-benefit analysis. In the present paper, a case study in a textile finishing company is presented. The study concentrates on the dyeing and printing sections. For each of the potential risks, several preventive measures have been identified and the corresponding costs and benefits have been estimated. Subsequently, the Benefit/Cost ratio (B/C) of these measures has been calculated, both in financial terms (from the organisation's perspective) and in economic terms (including the benefits for the worker and for the Society). Results show that, while the financial analysis in terms of the company does not justify the preventive measures, when the externalities are taken into account, the B/C ratio increases significantly and investments are fully justified.

1 INTRODUCTION

The International Labour Office (ILO, 2012) estimates that 2.34 million people die each year from work-related accidents or diseases worldwide. A further 317 million suffer from work-related injuries.

Safe and healthy workplaces help businesses and organisations to succeed and prosper and it also benefits the workers and the Society as a whole. Fewer accidents means less sick leaves, which results in lower costs and less disruption in the production process. It also saves employers from the expense of replacing the injured workers and/or recruiting and training new staff, and reduces the cost of early retirement and insurance pay-outs (EU-OSHA, 2012).

Money is the metric of business thus, there is a trend to make an evaluation of health and safety issues in monetary terms (Karwowski & Marras, 2003) though the existence of a natural aversion to reduce health and safety issues to financial terms.

When an organization performs an integrated analysis of risks in evaluating its Occupational Health and Safety (OHS) Management System, several steps are suggested to address risk situations. The organization should make a detailed analysis of the monetary impact (positive or negative) for the organization of each of the measures considered. However, it is also important to perform an analysis of the impact of each measure on Society, which corresponds to the so-called externalities. The measures taken by an organization in the prevention of risks can have a positive indirect effect (positive externality) on Society, while no action due to costs for the organization, can have a significant negative effect on Society (negative externality). Thus, these effects should be duly considered in decision-making regarding the adoption of preventive measures (Ramos et al., 2012).

Enterprises inevitably bear a substantial portion of the social cost of occupational injuries and illnesses through added expense and diminished

output. But it is likely that some of these costs are also externalized on workers as well as on society as a whole. A careful cost estimation exercise involves the quantification of the extent of several key potential externalities (ILO, 2012).

The workers are not fully compensated by their employers for the costs of job-related ill-health. Part of the expenses (wage lost and medical costs) is covered by insurance companies and social insurance systems. But the cost related to the loss of quality of life, borne by the workers and their households, should also be taken into account.

On the other hand, the State and Society as a whole has to cover the expenditure of hospitalizations, treatments and recovery, social benefit payments to injured workers, costs related to the reintegrating of the workers into the labour market. There are also implications in terms of productivity and competitiveness for the economy which should be taken into account.

Tomba et al. (2006) have made a survey of a large number of studies of workplace-based occupational health and safety interventions and concluded that very few economic analyses were undertaken amongst such a large number of workplace-based interventions. Indeed, economic analysis is rarely regarded as a critical component of an intervention related to OHS.

Cagno et al. (2013) have made a review of the economic evaluation of occupational safety and health and its way to SMEs, starting with more than 500 studies published since 2000. Despite differences in detail and/or terminology, most authors and institutions adopt the fundamental distinction between direct and indirect for valuing both costs and benefits. Cagno et al. (2013) concluded that this topic needs more multidisciplinary research.

In this context, cost-benefit analysis should provide answers to the following questions: What investments in OHS should be done? How much should be spent on preventive measures? When should each investment be made? (Ramos et al., 2012).

A robust, properly tested and systematized methodology for economic assessment in the context of risk management will support decision making within the OHS. The use of the Cost/Benefit Analysis (CBA) represents a natural extension of

ISO/IEC 31010:2009 in terms of techniques and tools for economic evaluation in risk management and assessment.

Table 1 explains the social benefits and costs in terms of their external and internal dimensions.

The authors have recently developed a model for Cost-Benefit Analysis in OHS (Ramos et al., 2012). This model permits to perform economic evaluations of risks and prevention initiatives from both the company and the society perspectives. It is an important tool to support managers and experts on economic analysis and decision making before starting any intervention project related to occupational health and safety.

The Health and Safety Executive (HSE) in Britain carried out a study on the total annual costs of accidents at work, taking average estimated values for the period between 2009 and 2012, as a reference (HSE, 2012). This study estimated that in Britain nearly 638,000 workers suffered occupational accidents every year, of which 368,000 were of low-gravity (with absence from work less than 4 days) and 271,000 with 4 or more days of absence. There were also 165 fatalities. As a result of these accidents, it is estimated that 16,000 workers had to leave work permanently. This study counts the cost of workplace accidents as a cost to the company, to the worker and to the Society.

The cost to the employer includes payments during the absence of the worker, insurance premiums, costs of production losses and administrative and legal costs.

Moreover, the costs to the employee include lost wages, compensation costs, health and rehabilitation costs and other costs. There are also non-financial costs that match the value of pain and suffering; the corresponding monetary value was estimated based on a methodology developed by Gordon et al. (1999). Finally, the costs to the Society should be considered. These include all costs not borne by employers or workers (e.g. costs related to the reduction of taxes, payment of benefits, medical treatment rehabilitation, administrative and legal related activities).

The studies of the Health and Safety Executive consider “costs to the government” as all costs resulting from the workplace accidents that are not

Table 1. Social benefits and costs.

| Benefits and costs | External | Private | Social |
|--------------------|--|---|--------------------------------------|
| Benefits | Agents who benefit from the positive externalities but do not pay for these advantages | Gains earned by agents who pay for | Sum of private and external benefits |
| Costs | Agents who suffer the negative externalities and who are not compensated | Costs paid by agents that have a direct benefit | Sum of private and external costs |

Table 2. Relationship between the cost to the worker, the Society and the company.

| Type of accident | $\frac{C_{\text{worker}}}{C_{\text{company}}}$ | $\frac{C_{\text{society}}}{C_{\text{company}}}$ |
|---|--|---|
| Accident that does not lead to sick leave or whose sick leave is equal to or less than 3 days | 0.67 | 5.33 |
| Accident leading to sick leave for more than 3 days | 4.22 | 1.30 |
| Fatal accident | 7.93 | 0.96 |

C_{worker} —Costs for the worker; C_{society} —Costs for the society; C_{company} —Costs for the company.

supported by the company or by the worker. Therefore, they can somehow be extrapolated as costs to the Society. Table 2 shows the relationship between the cost to the worker and to the Society in terms of the costs related to the company, depending on the severity of the accident—data calculated from the statistics published by HSE (2011).

These relationships allow us to make an estimate of the external costs to the company (externalities) from the computed internal cost of the accidents (from the perspective of the company).

The aim of the current paper is to present the application of the Cost-Benefit Analysis in OHS model in the textile sector.

2 CASE STUDY

The textile sector has many hazards that can cause injury to workers, from transport in the workplace, manual handling and working with dangerous machinery, exposure to noise, dust, contact or inhalation of chemicals, to the risk of slips from a wet working environment. Workers being struck by objects, such as moving machinery parts and vehicles are a significant cause of injury in the sector. There also exists the risks of fire and explosions, for example from heating plants used for vapour generation. Each processing stage from the production of materials to the manufacturing, finishing, colouring and packaging poses risks for workers, and some of these are particularly dangerous for women's health (EU-OSHA, 2008).

The case study presented here regards a Portuguese textile finishing company which dyes, prints and finishes knitted fabrics. The company has about 150 workers.

This study concentrates on two of the sectors of the company in which major work accidents have occurred in 2011 namely, printing and dyeing, chosen in collaboration with the company. These two

productive sectors employ about half of the workers of the company.

The occupational accidents in 2011 of these two sectors have been studied using official statistical indexes, which allowed prioritizing the measures to be implemented. Costs corresponding to these occupational accidents have been estimated.

In the present paper, we have used the simple methodology proposed by Heinrich (1959) to calculate the indirect costs of the accidents, as it is the system used by the company. According to this methodology, indirect costs can be estimated as being four times the direct costs, so the total costs are five times the direct costs.

The risk assessment process permitted comparing the results of the risk analysis and the criteria to determine the likelihood that the risk and/or the respective magnitude is acceptable or tolerable (ISO Guide 73, 2011). The risk assessment supports the decision about risk treatment. The company uses a simplified method to risk assessment.

As mentioned before, a risk evaluation has been made in the two sectors. Following this risk evaluation, a detailed plan of the preventive measures to be implemented has been designed, with an estimation of the corresponding costs.

An estimation of the benefits of these measures, in terms of the textile company and also for the society, has been made, based on the model developed by the authors (Ramos et al., 2012).

3 RESULTS AND DISCUSSION

3.1 Cost of accidents and preventive measures

Table 3 presents the total costs of accidents occurred in 2011 in the two sectors that have been studied. In each of the sectors, only one major work accident has occurred. These accidents have led to a temporary incapacity.

Total costs include both direct costs as well as indirect costs. As mentioned before, indirect costs have been estimated as four times the direct costs, as proposed by Heinrich (1959).

The costs are the same for both sectors, as the effects of the two accidents for the company were similar.

Table 3. Costs of accidents in 2011 on the two sector (in Euros).

| Sector | Direct costs | Indirect cost | Total costs |
|----------|--------------|---------------|-------------|
| Printing | 574 | 2,295 | 2,869 |
| Dyeing | 574 | 2,295 | 2,869 |
| Total | 1,148 | 4,590 | 5,738 |

The main preventive measures identified for the printing and dyeing sectors can be summarized as follows:

- developing information and training actions concerning correct ergonomic postures, the use of adequate personal protective equipment, awareness of electrical hazards, annual emergency simulation exercises, etc.
- implementation of a maintenance plan and verification of electrical/electronic equipment.
- delineate lanes for users.

The costs of these preventive measures have been calculated. The costs have taken into account the number of hours needed for information and training actions, including both the working time of the internal trainers and of the trainees involved in each service.

Table 4 presents the estimated costs in each sector.

3.2 Cost-benefit financial analysis

A simplified cost-benefit financial analysis (i.e. from the company perspective) has been made for all the preventive measures which can be adopted.

The benefits for the textile company are mainly linked to the reduction of the costs of the accidents. According to an optimistic scenario, supposing that the preventive measures have been well designed and will be successfully implemented, it has been estimated that there will be no accidents of the same type as those which happened in 2011 after the effective implementation of the preventive measures.

Table 5 presents the financial B/C (Benefit/Cost) ratio of all the measures in the two sectors of the company.

Table 4. Annual cost of all the preventive measures in the two sectors (in Euros).

| Sector | Total costs |
|----------|-------------|
| Printing | 5,287 |
| Dyeing | 5,451 |
| Total | 10,738 |

Table 5. Calculation of the financial B/C ratio of all the preventive measures in the two sectors (in Euros).

| Service | Benefits | Costs | B/C ratio |
|----------|----------|--------|-----------|
| Printing | 2,869 | 5,287 | 0.54 |
| Dyeing | 2,869 | 5,451 | 0.53 |
| Total | 5,738 | 10,738 | 0.53 |

As the B/C ratio is lower than 1, the preventive measures are not effective in financial terms, as the costs are higher than the benefits. Higher values of B/C ratio represent very effective preventive measures.

It can be concluded that the measures designed for the two sectors of the company are not cost-effective.

3.3 Cost-benefit economic analysis

The analysis of occupational safety preventive measures only in terms of the company results on an incomplete assessment of the impact of such investments. Thus, it is also important to perform an analysis of the impact of each measure for the workers and for the society, i.e., to measure the involved externalities.

To calculate the externalities we have used some questions from the model “Cost-Benefit Analysis in Occupational Safety and Health” of Ramos et al. (2012) and new items were also added, based on the study conducted by the Health and Safety Executive (HSE, 2012).

For the economic analysis it is important to take also into account the work incapacities resulting from accidents. The two accidents that occurred in the printing and dyeing sectors have led work incapacities, with 33 and 12 days of sick leave.

The economic analysis of measures to prevent the accidents is presented in Table 6, which includes the benefits for the worker and for the Society related to the reduction of accidents. Part of the intangible benefits was converted into monetary units, according to Table 3. The values presented concern the benefit related to each accident avoided.

Part of the intangible benefits was converted into monetary units, according to Table 3 (accidents leading to a sick leave of more than 3 days). Values refer to one accident.

To calculate the implications in terms of family stability, including pain and suffering, we used the amount of the second column of Table 3 and the average cost of accidents ($4.22 \times 2,869 \text{ €}$). The calculation of the reduction of family income was based on the total loss of salary (30%) for temporary incapacity in 2011 in the services studied (758 €) divided by the total number of accidents ($758/2 = 379 \text{ €}$). The implications in terms of productivity and competitiveness for the economy have been estimated using the amount of the third column of Table 3 and the average cost of accidents with falls ($1.30 \times 2,869 \text{ €}$).

Given that in 2011 there were two accidents in the sectors of the company that were studied and which are expected to be avoided after the effective implementation of preventive measures, the

Table 6. Economic benefits of preventive measures (for each accident avoided).

| Externalities | Related with | Benefit* (in Euro) |
|---|--------------------------------|---------------------------------|
| Implications in terms of family stability, including pain and suffering | Worker | Intangible, estimated at 12,106 |
| Reduction of the family income | Worker | 379 |
| Cost to the National Health System in terms of expenditure of hospitalizations, treatments and recovery | National Health System | Intangible, not quantified |
| Implications in terms of productivity and competitiveness for the economy | Society | Intangible, estimated at 3,729 |
| Other | National Health System Society | Intangible, not quantified |
| Total | | 16,215 |

*Economic benefit per type of accident.

benefits external to the company can then be estimated as being $2 \times 16,215 = 32,430$ €. Thus, taking into account only the external benefits that were quantified, the B/C ratio of these measures will be 3.6 (Benefits: $5,738 + 32,430 = 38,168$ € and Costs: 10,738 €).

This means that the profitability can be more than 3 euros for every euro invested. That is, while the financial B/C ratio considering only the benefits to the company, is only 0.53, which does not justify the investment, the economic B/C ratio, regarding the external benefits which were quantified, is 3.6, so the investments are fully justified in economic terms.

4 CONCLUSIONS

This paper presented and discussed the application of Cost Benefit Analysis (CBA) in Occupational Health and Safety (OHS)—CBAOHS—in the particular case of a textile company. This approach permits to perform an economic evaluation of risks and prevention initiatives from both the company and society perspectives.

Nevertheless, like all the techniques and tools, CBA has strengths and limitations (ISO/IEC 31010, 2009). In terms of strengths, this technique allows the comparison between costs and benefits using a single metric (money) and provides transparency for the decision-making process. On the other hand, some weaknesses can be identified, namely it requires detailed information to be collected, and benefits, which accrue to a large population, are difficult to estimate, particularly those relating to public goods, which are not exchanged in markets.

As ILO (2012) suggests, it would be important to carry out surveys at national level, in order to make a more accurate estimation of the part of the cost of the work accidents that are borne by the workers and of the Society, in a similar way as has

been done by HSE (2011 and 2012). In terms of the worker and their households, a survey involving a representative sample of injured workers, preferably on a yearly basis. The socially externalized costs could be estimated based on pre-existing data, such as the records of hospitals and public insurances.

As already mentioned by Pearce (1976), the results of cost–benefit analyses should always be interpreted with care, because estimates of the costs and the benefits of an intervention are never complete and rarely do justice to the complexity of the situation.

From the private perspective, the analysis of the financial Benefit/Cost ratio showed that, for the textile company considered in this case study, the preventive measures defined in the risk assessment process are not cost effective. The study can be refined by restricting the preventive measures, namely by reducing the type and duration of the training actions, in order to achieve a B/C ratio higher than 1, trying to improve the cost effectiveness of the measures.

The implementation of this model requires adequate planning and a precise definition of responsibility, involving professionals and company structures of the areas concerned. Therefore, taking into account the legal requirements that may exist in the organization, the implementation of this model should be coordinated by the Health and Safety manager, in close collaboration with a wide range of other professionals in the organization, with particular emphasis on the financial, management control and human resources departments (Ramos et al., 2012).

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