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Calculation of an adjusted Disproportion Factor (DF*) which takes the societal acceptability of risks into account

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ABSTRACT

This paper develops an approach considering parameters related to the societal acceptance of industrial risks, to determine an adjusted Disproportion Factor (DF*), whereby the pre-existing calculation model of the Disproportion Factor (DF) developed by Goose (2006) is used as the basis. Our approach will allow companies to have a much more realistic perception and coloured picture of decision-making, where societal acceptability is fully integrated into the calculation process. This way, the decision will not only be more accurate, but also be more defensible. After a literature review, 11 indicators were identified as relevant within the framework of prevention of disasters in companies. Factor analysis confirmed that the 11 indicators represent a societal acceptability of risks (SAR) concept. By using a scoring system we explain how an adjusted DF* can be determined. An illustrative example is also given to show how the model can actually be used. This study thus provides a scoring system that could be used by risk managers in order to include the societal acceptability of risks (SAR) into economic analyses of industrial risks.

1. Introduction

When talking about how safety concerns are taken into account by stakeholders, economic analyses like cost-benefits analysis (CBA) and cost-effectiveness analysis (CEA) are often used in the decision-making process. What is more, in the UK for example, companies and industrials are even obliged to prove that a risk has been reduced to so-called "so far as is reasonably practicable" (SFAIRP). A possible way of proving SFAIRP is by employing a so-called Disproportion Factor (DF). The model of a disproportion factor (DF) came from the idea of using an intended bias to better support safety over costs. That is why it is sometimes used by risk managers to prove that a further risk reduction is not worth the cost when compared to the benefit in matter of risk reduction and safety management for major accident prevention. This economic model was developed by Goose in 2006. The required input information and calculation method will be briefly described in this paper in order to understand how this model works and can be used.

More particularly, the proportion factor (PF) can be defined as the ratio of the costs to the benefits $\left(PF = \frac{Costs}{Benefits}\right)$. This ratio is then compared to the numerical value of the estimated disproportion factor (DF) in order to determine whether the risk reduction measure can be qualified as 'grossly disproportionate' or not. This estimated value is calculated thanks to the use of three numbers which can be extracted from an FN curve (as it is possible to see in Fig. 1):

- The sum of the failure rates, written $\sum FR$, and expressed in events per year.
- The expectation value (EV) which is also called Potential Loss of Life (PLL) represents the average number of casualties expected per year. As shown in Fig. 1, this is the area under the FN curve.
- The maximum number of potential fatalities, written N_{max}, representing the worst case scenario consequences with respect to the number of people killed for a single event.
- A fourth value can be calculated with the ratio of EV to $\sum FR$, representing N_{av}, that is, the average number of fatalities per event, written $N_{av} = \frac{EV}{\sum FR}$.

The calculation method gives an order of magnitude for the disproportion factor and therefore it is possible to make comparisons

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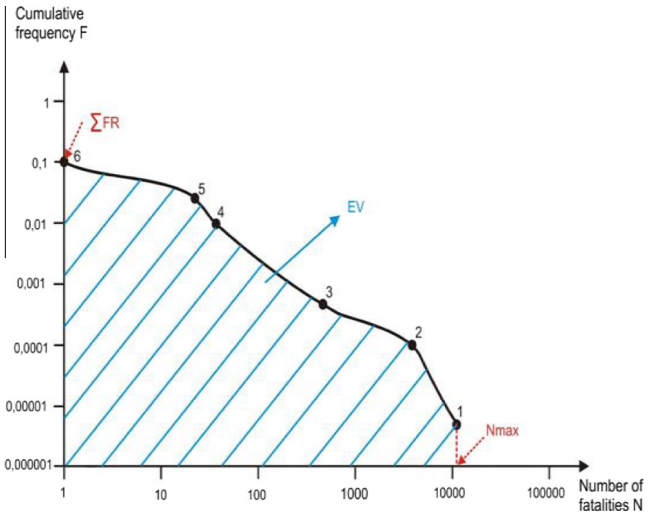

Fig. 1. Illustrative FN curve and input information for the *DF* calculation.

between different scenarios and major historical accidents. The global formula used to calculate the *DF* is composed of the multiplication of the three 'How' factors and the addition of the number 3 (in order to be sure that safety is focussed upon):

$$DF = \text{'How bad'} * \text{'How risky'} * \text{'How variable'} + 3$$

Each 'How factor' is estimated individually with a similar formula:

$$\text{'How bad'} = log_{10}(N_{av})$$

$$\text{'How risky'} = log_{10}(10^5 * EV)$$

$$\text{'How variable'} = log_{10}\left(\frac{N_{max}}{N_{av}}\right)$$

Unfortunately, there are no moral aspects included in the DF model other than the number of fatalities. That is why the idea here is to take "societal acceptance" into account which can be viewed as public consent about management practices. This definition closely comes to the one given by Sandman (2012) using the level of outrage as a proxy of societal (in) acceptance. Societal Acceptability of Risk (SAR) can also be linked to the notion of Social License to Operate (SLO) described by the non-profit organization called Business for Social Responsibility (2003). The idea is to be able to avoid situations with tensions between surrounding communities or employees and other shareholders. Furthermore SAR can be seen as social expectations which, if not met, create oppositions that could delay the production, increase certain costs and even compromise new projects. There are several possible impacts due to local oppositions: reputational damage, share prices decreases, low motivation of employees or even poor attractiveness of new employees. SAR has been studied for decades from different perspectives but remains very disputable because it tries to model and predict human behaviour and response which is a very complex issue involving many fields and disciplines such as for example social sciences, psychology, sociology, safety science and risk analysis.

2. Literature study

2.1. Risk perception and societal acceptability

In 1978, Fischhoff et al. described a psychometric study in which was demonstrated that feelings of dread were the major determiner of public perception and acceptance of risk for a wide range of hazards. A psychometric questionnaire was used in order to correlate nine characteristics of risks resulting in two main factors. The factor "dread risk" included the following items: perceived lack of control, catastrophic potential, inequitable distribution of risks and benefits and, fatal consequences and dreadful. The "unknown risk" factor consisted of the items observability, experts' and lay people's knowledge about the risk, delay effect of potential damage (immediacy) and novelty (new-old).

In a study by Huang et al. (2013), the goal was to find correlations between public perception of the chemical industry and its acceptance in matter of risks. Based on a survey administered from 1190 participants, four different factors related to social acceptance were found, each one being subdivided into two subfactors. The first factor, 'Knowledge', consists of a newness factor and a knowledge factor. The second factor, 'Benefit', consists of the benefit and immediacy together. Then 'Effect' matches with the third factor and is divided between social effect and dread. Finally, 'Trust' is the last one, including controllability and trust in governments.

The four factors were then linked with social acceptance through a regression analysis. It is however important to precise that knowledge should be understood from the perspective of citizens' points of view and the social effect actually implies 'How many citizens are exposed to the risk?'. Moreover, the factor 'trust in government' concerns also related policy makers in a broader sense.

In a study by Gurian (2008), the focus was more on how risks are perceived and considered by the general public and society rather than to focus on the industry's point of view. Based on theoretical explanations, Gurian defined three factors that influence risk perception. The first one is called 'Dread' and includes gut level (related to intuition), the emotional reaction due to risk, threat to future generations, control over the risk, equitability and catastrophic potential. The second factor, 'Familiarity', was composed of delayed effects, newness, understood by science or not, and encountered often by the public or not. Finally, the last factor was about the 'number of people exposed to the risk'.

Adams (2009) used the Risk Thermostat model to describe perception of risks and again a new classification of risks is given depending on 3 main factors which are voluntariness, individual control and profit motivated. The acceptability model developed by Adams and resulting from the risk thermostat model is shown in Fig. 2.

This study is very similar to Gurian (2008), Fischhoff et al. (1978) and Huang et al. (2013) since it focused on the perceived levels of risks to laypeople.

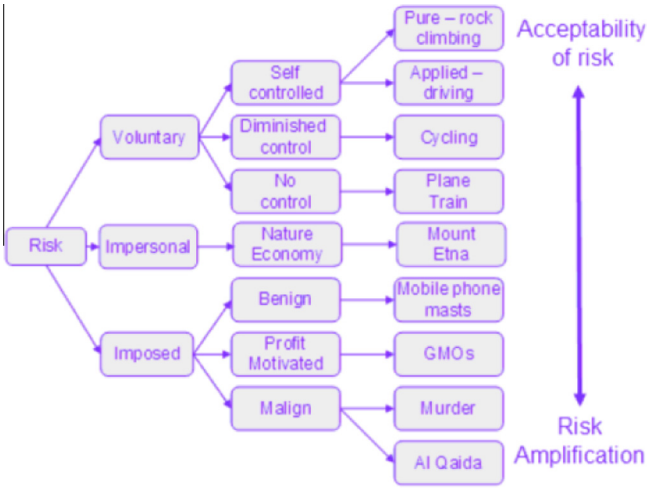

Fig. 2. Acceptability model developed by Adams (2009).

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