# Teaching Safety Risk Management: On The Importance Of Integrating Economic And Safety Perspectives

Eirik Bjorheim Abrahamsen
Department of Safety, Economics and Planning, University of Stavanger, Norway

Jon Tømmerås Selvik
Department of Safety, Economics and Planning, University of Stavanger, Norway

Frank Asche
School of Forest, Fisheries, & Geomatics Sciences, University of Florida, USA
Department of Safety, Economics and Planning, University of Stavanger, Norway

Maria Francesca Milazzo
Department of Engineering, University of Messina, Italy

Håkon Bjorheim Abrahamsen
Department of Safety, Economics and Planning, University of Stavanger, Norway
Department of Anaesthesiology and Intensive Care, Stavanger University Hospital, Norway

## ABSTRACT

When teaching risk management, within the area of safety, the main focus is typically on safety management principles. The basis for these principles, and for traditional safety thinking, is the adoption of a cautionary mindset (cautionary principle), where attention is given to uncertainty, what could happen in the future and how to reduce or avoid possible consequences. In this paper, we point out the importance of also paying some attention to economic principles, to facilitate good resource utilization. Resources are in general scarce, and a stronger weight placed on the uncertainties than should be done from a traditional economic perspective may contribute to a sub-optimal use of resources. Even if the scope is limited only to risk management, negative impacts on safety may then occur. However, as the traditional economic perspective in some situations may also contribute to too little weight being placed on the uncertainties, we argue for the importance of integrating safety and economic perspectives when teaching safety risk management.

Key words: teaching, higher education, risk management, safety, economic perspectives, safety perspectives, uncertainty

## INTRODUCTION

Risk management refers to coordinated activities to direct and control an organisation with regard to risk (ISO 31000, 2018) and, as such, addresses the challenge of balancing value creation and risk. When teaching risk management, within the area of safety, the focus is usually on the importance of giving strong weight to the uncertainties and to the potential for accidental events to occur (Abrahamsen and Abrahamsen, 2015; Abrahamsen et al., 2018; Möller and Hansson, 2008), with a principle of caution when facing uncertainty and potentially severe events being adopted. Aven (2019) refers to it as a 'cautionary principle'.

In this paper, we ask whether safety management principles and strong weight placed on the uncertainties should be the only basis for safety risk management. The question is fundamental and principally important for ensuring good quality in teaching safety risk management and candidates that are equipped to take part in the

decision processes in various organisations. The question is of special interest, as the prevailing safety thinking, which forms the basis for teaching safety risk management, is in clear contrast to the economic thinking, where decision-making is based on expected value considerations (Varian, 1999). This may marginalise the impact of safety science and lead to outcomes where limited weight is then given to the uncertainties and the potential for extreme consequences to occur.

With reference to the difference between safety and economic perspectives, in this paper, we discuss whether the economic principles, theories and methods should be incorporated into safety risk management. We show that traditional economic thinking must be incorporated and should be considered an equally important element as the ruling principles in safety management. Without integrating the economic and safety perspectives in safety risk management, the basis for giving good decision support and thereby facilitating good decisions is weakened. We highlight that such a focus is of crucial importance when teaching safety risk management.

This paper is organised into five sections, including the introduction section. Section 2 provides a brief presentation of the safety expert's approach to safety risk management. Attention is paid to prevailing safety management principles, such as the cautionary- and precautionary principles and the ALARP principle. Section 3 focuses on the economist's approach to safety risk management, where the focus is on economic principles, theories and methods. In section 4, we discuss whether the integration of economic and safety perspectives when teaching safety risk management is important or something to avoid. Finally, in Section 5, we draw some conclusions.

## A SAFETY EXPERT'S APPROACH TO SAFETY RISK MANAGEMENT

As already mentioned, risk management refers to coordinated activities aimed at directing and controlling an organisation with respect to risk. From a safety expert perspective, the approach to risk management (HSE, 2001) typically includes:

- identifying what could cause injury or illness in the workplace (i.e., identifying the hazards)
- deciding how likely it is that someone will be harmed and how seriously (e.g., quantifying the risk)
- intervening to eliminate the danger or control the risk (i.e., managing the risk)

The process covers a variety of sub-tasks aimed at establishing a continuous improvement framework for managing risk. This framework integrates a set of principles and a process for how to perform risk analysis in general (ISO 31000, 2018). An objective is to strengthen risk-informed decision-making. Within this scope, there are several tools and principles, in addition to traditional risk analysis. For instance, the economist's toolkit includes expected utility theory, cost-benefit and cost-effectiveness analysis and expected net present value. However, in real-world applications, a challenge is to understand the strengths and weaknesses of different approaches.

Uncertainty might be highlighted as a main attribute of risk. In addition to uncertainty, Aven (2018) also points to the consequences of the activity. These consequences represent a value judgment. When describing the risk, the assessor would then combine the potential consequences, which could be a potential economic loss, and the associated uncertainties must also be expressed. These are often expressed using probabilities. Both attributes are assessed, i.e., the consequences and uncertainties, conditional on the knowledge of the one(s) analysing the situation (Abrahamsen et al., 2018). Hence, two different analysis teams may assess the risk differently, as they might have a different understanding of what might happen and how likely it is.

From a safety expert's approach, the cautionary principle will guide the emphasis of risk in the situation of interest (Aven, 2019). For situations with a significant potential for severe consequences, it is seen as reasonable to mitigate these or to avoid them entirely. According to Aven (2019), the cautionary principle states that: "in the face of an activity subject to serious consequences or uncertainty, cautionary measures, such as implementing risk-

reducing measures or not carrying out the activity, should be taken". Aven and Vinnem (2007) add that the need to be cautious when working with risk and uncertainties is also reflected when designing safety regulations.

Sometimes, when there is significant "scientific uncertainty" regarding the consequences, a variant of the cautionary principle is referred to, i.e., the precautionary principle. This variant states that if "the consequences of an activity could be serious and subject to scientific uncertainties, then precautionary measures should be taken, or the activity should not be carried out" (Aven, 2019). This emphasises the need to be careful, particularly in situations where there is lack of understanding related to what might happen.

Focusing on the cautionary principle in general, one way to operationalise this is to have risk reduced to a level that is As Low As Reasonably Practicable (ALARP). When managing risk according to ALARP, considered measures should be implemented unless they are grossly disproportionate to the obtained benefits (HSE, 2001). This is a way to place weight on safety aspects in decision-making, as any risk-reducing measure should be implemented, unless there is a strong argument against it (Abrahamsen et al., 2018). The argumentation is typically derived through traditional cost-benefit analysis (Ale et al., 2015).

Aven (2011) is critical of decision-making based solely on expected values, being the premise for cost-benefit analyses. To ensure ALARP leans more towards protection than value creation, a layered approach, capturing underlying uncertainties, is proposed (Aven, 2011). This is a three-step approach: Step 1 being a crude analysis of costs. If the costs are low, the measure should be implemented; there are not strong enough arguments against it. For higher costs, a more detailed analysis is called for, which is performed in Step 2 by a cost-benefit analysis. If this analysis gives a positive result, then the measure should be implemented. For a negative result, where expected costs are higher than expected benefits, one should move to Step 3. In this, a checklist is referred to for the assessment of other issues, such as level of uncertainty and manageability concerns (see, e.g., Abrahamsen et al., 2018).

## AN ECONOMIST'S APPROACH TO SAFETY RISK MANAGEMENT

According to the economist's perspective, the expected utility theory is fundamental for making decisions in situations characterised by uncertainty (see e.g., Bedford and Cook, 2001; and Levy and Sarnat, 1994). The theory provides a logical framework for making decisions under uncertainty, using a probabilistic approach. It represents an optimal way for someone consistent in consequence uncertainty judgements to make decisions (Lindley, 1985). However, despite its logical and theoretically attractive appearance, a main obstacle is the challenge of measuring utility (Lindley, 1985). Hence, there are simplified approaches, consistent with maximising expected utility, but in which the simplifications are introduced through additional assumptions. The most common of these tools is the traditional cost-benefit analysis. In this, all attributes covering the utilities are expressed as costs and benefits in terms of monetary values, which traditionally reflect the amount society would be willing to pay to achieve some resource or to obtain a specific benefit (Varian, 1999). Monetary values are easily comparable and are generally not as difficult to determine, compared with non-market goods (Abrahamsen et al., 2011).

In benefit cost analysis, the pros and cons of an activity or project are assessed and expressed as an expected net present value, E[NPV]. For the calculation of the E[NPV], costs and benefits must be specified for the relevant periods, with a discounting rate (Levy and Sarnat, 1994). The sum of the expected benefits and costs in a given period t, $E[X_t]$, is given by the estimated costs and benefits occurring in that period. For a typical safety investment, in the first period there will only be costs, as this involves the cost of setting up the measure. In later periods, the expected benefits are calculated as the expected value of avoiding accidents, and the expected cost will be the cost of maintaining the safety measure. The $E[NPV(r_t)]$ is calculated by the following expression:

$$E[NPV(r_t)] = \sum_{t=0}^{T} \frac{E(X_t)}{(1+r_t)^t} \quad (1)$$

which gives the net present value of the measure over its lifetime from time 0 to $T$ (often in years). In (1), $r_t$ denotes the (expected) discount rate for year $t$. For the time period considered, the discounting of the cashflow by an appropriate rate of return will reflect the impact of benefits and costs occurring at different time periods in the E[NPV]. To adjust for, e.g., compensation expected in risk-taking, Varian (1999) points to the Capital Asset Pricing Model (CAPM). We refer to Varian (1999) for further details.

In the cost-benefit analysis, the analyst should include all relevant attributes, such that all pros and cons are accounted for in the result. The measure is beneficial if the E[NPV($r_t$)] is positive, and the expected costs are larger than the expected benefits if it is negative. The underlying idea is that, when the value for all the attributes is accounted for, a positive expected net present value will ensure projects with the best use of the decision maker's resources (Varian, 1999). A premise is then that all attributes are expressed in monetary values, which some argue is challenging, as there could be non-market, intangible goods that it is immoral and illogical to monetise (Ale et al., 2015; Aven and Kørte, 2003). However, economists will argue that, if one is not comparing all values to a common unit, money, they can deduce the implicit value of different alternatives to the decision maker, based on their incurred expenses on resources (Viscusi et al., 2019). As such, making the conversion to money makes the basis for the decision transparent.

An alternative that accounts for the criticism that there are things that should not be given a monetary value is the cost-effectiveness analysis. Such an analysis is carried out without explicitly specifying the monetary value of benefits, only the costs. It allows non-monetary indices. For example, for situations with the potential for loss of lives, expected cost per expected saved life can be used instead of the value of a statistical life (Abrahamsen et al., 2004). This will give the same outcome if the measure has only one effect, i.e., the number of saved lives. However, it becomes more problematic if there are different outcomes. For instance, how does one compare the cost of a saved life to the cost of avoiding serious injury?

There are also other alternatives, e.g., multi-attribute analysis, presenting the effects for a range of attributes, without converting them into comparable units; return of investments, which measures the expected return relative to resources invested; it also possible to perform cost-benefit analysis in a more pragmatic way, by avoiding any reference to objective correct values and non-market goods (Aven, 2014).

## ON INTEGRATING ECONOMIC AND SAFETY PERSPECTIVES WHEN TEACHING SAFETY RISK MANAGEMENT. USEFUL AND IMPORTANT OR SOMETHING TO AVOID?

As we have seen from the previous sections, different perspectives exist regarding safety risk management. When teaching safety risk management, attention is mainly given to safety perspectives. Strong weight is then placed on the uncertainties. The question is then whether or not it is useful to incorporate economic thinking when teaching safety risk management.

Firstly, from an economist's point of view, decisions under uncertainty should be based on expected values, as described in the previous section (Varian, 1999); this is to ensure the efficient use of resources. In safety literature, several authors are critical of the practice of decision-making under uncertainty, where decisions follow from the calculation of expected values alone (Ale et al., 2015; Watkiss et al., 2015; Abrahamsen et al., 2004). In addition to the argumentation that monetising non-market goods might be challenging, there is a claim that expected values give insufficient weight to associated uncertainties and that relevant background knowledge is ignored. Background knowledge is fundamental for the calculation of the expected values. An example of this is a project being part of a portfolio, in which project outcomes could be severe. One may, for this project, question whether it is acceptable to ignore unsystematic risks. From an economic perspective, it might be, if there is a risk attitude in conflict with cautionary thinking. It should be added that expected values in general do not necessarily give good predictions of what will be the actual outcomes. The actual outcomes (consequences) could be severe,

despite a low expected value. Abrahamsen et al. (2004) argue that, in general, expected values should be used with care and also that there is a need to somehow better reflect associated uncertainties.

In relation to the use of expected values, Langdalen (2020) points also to the effects of corporate procedures. Corporate procedures refer to a collective mindset inside an organisation. One could perhaps argue that the mentioned portfolio will consist of some projects supported by weak knowledge and some by strong, in total summing up to around zero, and making the strength of knowledge for individual projects less important. Abrahamsen et al. (2004) argue that such thinking is flawed, as the corporate procedures will not be perfectly diversified. It will be possible, in some way, to influence the portfolio value, without the decision maker being fully aware that it is happening.

Based on the above arguments, we may ask whether a focus exclusively on safety management principles is appropriate and should be the prevailing practice when teaching safety risk management – without special attention being paid to economic principles, theories and methods.

We believe that such a focus is unfortunate as a basis for teaching safety risk management. However, despite the challenges in using expected values, there are also benefits in the context of safety risk management (Abrahamsen et al., 2017). Specifically, in situations characterised by low uncertainty, strong knowledge and minor expected consequences, it is difficult to argue against a decision-making approach with reference to $E[NPV(r_t)]$. Greater emphasis on uncertainty than is the case through expected values will only lead to limited resources being used sub-optimally. A result will very likely be less safety from the available resources/money. For such situations, adopting safety management principles and the prevailing safety thinking may give less safety.

We will argue that the basis for good risk management is to think dynamically, meaning that, in some decision-making contexts, one should make automatic decisions using expected values, while, in other contexts, strong weight should be given to the uncertainties, with no link to cost-benefit analyses. In most cases, one will find oneself between the two extremes.

One concrete approach is to adopt a fully dynamic approach for decision-making under uncertainty by using the ALARP-principle, as suggested in Abrahamsen et al. (2017; 2018). There are different ways to interpret this principle. It may be interpreted in a highly conservative way, with strong weight being placed on uncertainty in all situations. Clearly, there would then be situations where such an approach becomes too strict. The principle could also be interpreted such that the situation would influence how much weight is given to uncertainties. This means that, in some situations, ALARP may be demonstrated with reference to cost-benefit analysis, and without any refence to such analysis in other situations (Abrahamsen et al., 2017). Abrahamsen et al. (2017) state that, if ALARP is to function as a general decision-making principle, "[...] it must be interpreted in a way that allows it to range from one extreme to another, i.e., a dynamic way, as it is not considered appropriate to adopt a static decision-making principle that covers all possible decision-making contexts".

The above message, on the importance of giving different weight to the uncertainties for different decision-making contexts, should form the basis for teaching safety risk management. Without such a focus, one will form a basis for the field that is inappropriate. In some situations, one will then place too much weight on the uncertainties. The scarce resources will not necessarily be used optimally. Given the available resources, less safety can then be the result. In other words, we may say that, in some situations, the prevailing safety thinking may be a threat to safety. In the same way, we may also say that focusing solely on economic theories, methods and principles when teaching safety risk management will be inappropriate from a safety point of view. Too little weight will then, in some situations, be given to the uncertainties.

It is far from an easy task to determine how much weight to place on uncertainty when balancing value creation and protection. When determining this, both economic and safety perspectives might be justified, and the optimal or appropriate way is typically a mixed approach and not an extreme one (see Aven, 2019). Aven and Kørte

(2003) add that, to follow up on the analytic results, 'managerial review and judgment' have a role in informing the decision-making, by taking into consideration the decision-making context and various aspects of relevance (e.g., policies, uncertainties and other analyses). Those making the decision will then typically have to make trade-offs in balancing value creation and protection.

When managing risk in a situation, there could be competing values and objectives, and the tools selected to assess the best way, whether strategic or principle-based, might produce different results. In addition, as already indicated, a weak knowledge base could challenge the quality, by producing misleading decision-support. There could be uncertainties concealed because of this, as the analysis might be based on weak assumptions (Patè-Cornell, 2002). Hence, it is important to capture and inform the decision maker about both the level of uncertainty and the strength of knowledge associated with the results communicated.

## CONCLUDING REMARKS

In addition to the cautionary principles typical to risk and safety thinking, economic principles should also play a key role when teaching risk management. Economic principles add to the balancing of value creation and protection by facilitating proper resource utilisation. However, as there are usually limited resources available, too much weight on uncertainties compared to the traditional economic perspective may contribute to a sub-optimal use of resources. Even if the context is strictly risk management, negative impacts on safety may then occur. On the other hand, the traditional economic perspective might, in some situations, also contribute to too little weight on the uncertainties, and we argue for the importance of integrating both safety and economic perspectives when teaching safety risk management.

The importance of economic thinking is widely covered in risk management literature, and many of the models developed to support safety risk decision-making build on economic thinking. Hence, we argue that is also of crucial importance to better integrate economic and safety perspectives when teaching safety risk management. Economic thinking has a role to play as a navigator in ensuring acceptable resource utilisation, which is not achieved by adopting a strictly cautionary mindset. It is only when safety and economic perspectives are integrated that the foundation is set for achieving good teaching in safety risk management.

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