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Advances in safety risk management

Introduction

Managing risk is challenging for any organization, and with a seemingly endless stream of disruptive and even catastrophic events taking place, there is an increasing emphasis on preparing for the worst. However, being focused on the negative aspects of risk, without considering the positive attributes, may be shortsighted. Playing it safe may not always be the best policy, because great benefits may be missed.

Within the area of safety, different perspectives exist on how to provide an adequate basis for managing risk. Safety experts emphasize the cautionary principle, stating that in the face of uncertainty, caution should be the dominant standard. On the other hand, relying on economic assessment often leads to decisions made focusing on expected values to optimize return on investment. *Safety Risk Management: Integrating Economic and Safety Perspectives* aims to illuminate this dichotomy while debating important questions. For example, is 'safety always first'?

Risk management deals with balancing the dilemma inherent in exploring opportunities on the one hand, and avoiding losses, accidents, and disasters, on the other. *Safety Risk Management: Integrating Economic and Safety Perspectives* comprises a collection of work in this field with special focus given to situations with the potential for substantial reward but also with the possibility of immense losses and extreme consequences.

This book aims to contribute to clarifying the problem by proposing an appropriate basis for managing risk to meet related practical challenges. In this overview, we preview the book which consists of two parts: chapters covering fundamental concepts and approaches; and, chapters illustrating applications of these fundamental principles.

Fundamentals

Every enterprise must manage both internal and external risks. Exploiting risk necessitates thoroughly understanding the overall risk environment and using that understanding to proceed with making decisions and implementing those decisions. The practices and decisions used to exploit risk may be assessed according to various criteria, and for organizations, may include the level to which they meet or exceed competitive and regulatory requirements. They may be based on applying analytical decision-focused methodologies, as well as on using behavioral approaches to better navigate economic, technological, and political environments.

Analyzing decisions appropriately involves using both known benefits and costs, and unexpected benefits and unexpected costs. The unexpected components may turn out to outweigh the initial known information. One conservative approach is to employ the precautionary principle. Using the precautionary approach may involve foregoing an alternative, to avoid unexpected costs, but may mean foregoing some unexpected benefits. An example would be risks involving potential accidents, where in order to avoid potential accidents, possible benefits are foregone.

The chapter by Holmes Miller and Kurt Engemann develops an argument for using a comfort-based criterion to pursue the “glass half full” approach. They argue that doing this may enable a decision maker to enjoy both the expected and unexpected benefits that might accrue from a new product or technology, enhance organizational processes, and solidify competitive advantage. They discuss some benefits, methodologies, and overall strategies to support the process of exploiting risk.

Their chapter focuses on discussing an analytical approach to risk. Two analytical approaches are the classical regret-based approach, and the new comfort-based approach. The regret-based approach looks at the world from a “glass half empty” perspective where, whatever outcome occurs, the decision maker ranks it in relation to the best possible outcome. In this respect, one focuses on dissatisfaction as a criteria, and has a sense of entitlement, always striving for more. The comfort-based approach is a “glass half full” approach where the decision maker looks at outcomes relative to the worst outcome (Engemann and Yager, 2018). With this criteria, the decision maker enjoys a sense of gratitude by focusing on the degree of satisfaction achieved, rather than what has been missed.

The psychology of risk is a complex subject. Risk, as a construct, is one which the human mind, singly and collectively, is likely to reason inconsistently and/or irrationally (Breakwell, 2014). A Safety Science approach has a goal of minimal risk level at acceptable cost. This long-established approach to Safety Science is being challenged by techniques used in the emerging field of Enterprise Risk Management, featuring an econometric risk management approach that focuses on cost/benefit optimisation while maintaining an acceptable risk level. The chapter by Sophia Langley seeks to understand whether Enterprise Risk Management approaches do indeed offer benefits over conventional Safety Science in safety-critical scenarios, or if they could, in fact, fail to transfer to this application area and have the potential for detriment. The chapter concludes that these two approaches have inherently different application criteria and specifies the conditions necessary to implement a hybrid approach which uses the best of both. Multiple safety goals, both qualitative and quantitative, may need to be recognised in any holistic approach to complex safety scenarios.

Despite some challenges, cost-benefit approaches and socio-economic profitability have been the guiding principles for the implementation of safety measures, aiming to contribute to good policy-making through systematic analysis of the costs and benefits of various policy approaches (Adler, 2011). However, compared to safety risks, security threats are events associated with a high degree of uncertainty,

ambiguity and complexity. Some security risk problems are harder to deal with than others. A class of risk problems, referred to as transboundary wicked problems, include risks such as terrorism, international organized crime and cyberattacks, transcend the distinctions between cause and effect, local and global problems, and facts and impressions (Noordegraaf et. al. 2017). Transboundary wicked security problems are low-probability attacks, with a possibility of immense losses. In their chapter, Sissel Jore, Eirik Abrahamsen, Henrik Langdalen and Jon Selvik discuss the use of socio-economic profitability as fundamental for investments in security measures. They argue that the profitability of security measures must be assessed in a broader context than is the case in a traditional cost-benefit analysis and that, despite the challenges associated with measuring the benefits of security measures, it is important to visualize the uncertainties accompanying these benefits, so that decision-makers can make informed decisions about the implementation of security measures.

The precautionary principle (Sandin, 1999) states that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. The precautionary principle has traditionally been analyzed from the perspective of one decision maker at the societal level, usually abstracting away strategic interaction. The chapter by Kjell Hausken provides a game theoretic formalization of the precautionary principle and analyzes the precautionary principle from the perspectives of multiple players. Examples of players include various branches of government, entrepreneurs, consumers, organizations, citizens, countries, criminals, and terrorists. Challenging precautionary principle considerations involves who the players are, which game is played, their strategy sets, preferences, beliefs, information, risk attitudes, and bounded rationality.

Establishing monetary values is a challenging part of a risk analysis, and the main topic in many controversies pertaining to cost-benefit analysis. Assigning monetary values to human life, health, and the environment is fundamentally difficult (Ackerman and Heinzerling, 2002). A major accident is typically considered as such because it is associated with a huge impact on human life, the environment and/or economic values. A priori probabilities for such incidents are often very low, while the consequences are substantial. The chapter by Torleif Husebø discusses why it is difficult to use cost-benefit analysis as a tool in the decision-making process where major accidents can occur. The emphasis is primarily on socio-economic issues in public regulation of safety, but the principles are also relevant to the private sector when decisions on safety related issues are made. The aim is to demonstrate that the frequently used principles of treating uncertainty based on the portfolio theory is challenging when dealing with major accident events. In such cases a broader perspective, compared to the traditional method of expected values, needs to be applied. Consideration should be given to a comprehensive perspective of both qualitative and quantitative descriptions of costs and benefits that influence the decision-making process.

Decision making is often driven by factors which are not expressible in monetary units. When discussing security measures to protect critical infrastructures there is on the one hand a need to compare quantifiable criteria like financial costs, and numbers of fatalities and injuries, on the other hand. Multi-Criteria Decision Analysis (Saaty and Vargas, 2012) provides evaluation methods dealing with both qualitative and quantitative criteria. The chapter by Peter Klein undertakes to extend this methodology to integrate both quantitative and qualitative criteria in one common assessment, with respect to the special circumstances of critical infrastructure protection. The chapter provides a discussion of how to assess tangible and intangible costs and benefits of complex security measures in a holistic approach.

Applications

Safety management is a complex process for organizations involved with major hazards. Operators usually use standards as a guide in risk analysis management. Given the complexity of handling dangerous substances, safety management is closely linked to the resources available to an organization. For example, in the petroleum industry, fully comprehensive inspections involving all equipment is cost prohibitive, especially for huge refineries. For this reason, the use of a risk-based inspection approach is recommended (Vianello et al. 2016). Application of risk-based inspection promoted by the American Petroleum Institute supports reliability and reduces maintenance costs through a prudent selection of risk reduction strategies. Nevertheless, performing a risk-based inspection is a complex task due to the amount of data involved. Several tools offer support in formulating decisions that involve economic issues. Amongst these, the *Inspection Manager* software appears to be an effective tool, and includes models comparing prevention and mitigation measures of accidental events, caused by the release of hazardous materials, and cost-benefit analyses. In their chapter, Chiara Vianello, Maria Milazzo and Giuseppe Maschio describe the usefulness of the *Inspection Manager* through the application to a case study that refers to a hydrodesulphurisation unit of a refinery.

For production facilities in the oil and gas industry, a key activity is to specify when to perform various periodic tests of safety critical equipment. The test periods may be determined by modelling the degradation of the equipment. A reasonable way to select the optimal time between successive maintenance activities is to use a model which gives the difference between the point in time when the indication of a potential failure can first be detected and the point of time when the item has failed (Rausand and Høyland 2004). Based on the information, one can compare the expected costs of testing, repairs or replacements, and of the potential failures. In their chapter, Jon Selvik and Eirik Abrahamsen argue that such a decision principle based on expected costs depends on the situation. They suggest using a

dynamic decision principle that allows for situation-based decision support. This recognizes that decision-making should go beyond the use of expected costs, particularly in situations with high vulnerability and a high score reflecting probability of failure versus uncertainty. An example from the oil and gas industry is included to show how the decision principle can be selected and applied.

Safety is a characteristic of reliability, a dynamic non-event (Weick, 1987). Safety and reliability, while critical operational outcomes, are challenging to adequately envision and manage. Stock car racing is a setting where safety and reliability are unwaveringly important to the viability of the sport. However, the high-risk operations embedded within the sport often obscure how one evaluates safe and reliable performance, and the likelihood of death, injury, and property damage, as a consequence of an error on the race track remains. In their chapter, Krista Engemann and Cliff Scott glean insights and implications from stock car racing, its associated American governing institution, NASCAR, and pit crews, to further the understanding of safety and reliability in organizations at large.

Selecting safety measures, with respect to flood and landslide risks, without proper consideration of the vulnerabilities may be socio-economically futile, as the vulnerabilities of an affected area shape the real loss caused by an event (Birkmann, 2013). The Norwegian Water Resources and Energy Directorate is a public body, which is responsible for improving Norway's ability to control floods and landslide risks. The Norwegian government's state that the prioritization and ranking of safety measures must be risk-based, and that socio-economic profitability should be the guiding principle for the prioritization. Prioritizing safety measures with reference to both risk and socio-economic profitability is challenging. A framework, which merges a risk-based approach and a cost-effectiveness approach was established, such that safety measures can be prioritized according to both criteria. Nevertheless, prioritizing by both risk and cost-effectiveness is not always consistent with selecting the projects that have the most need for safety measures. In their chapter, Henrik Langdalen, Eirik Abrahamsen, Jon Selvik and Hallvard Berg seek to achieve a more risk-informed prioritization of which safety measures to select, by extending the established framework with considerations of the flood and landslide vulnerabilities. This provides improved decision support for enhanced prioritization.

The chapter by Rune Elvik discusses the changing role of cost-benefit analysis in road safety policy analyses in Norway based on a theory that road safety policy is cyclical. There are two policy cycles: contraction and detraction. Contraction uses policy interventions that can be implemented on short notice like enforcement, penalties, legislation and low-cost road investments. Detraction is characterised by lowering the priority given to road safety measures. A trend can be seen for policy ambitions for improving road safety to increase as the number of fatalities has gone down, consistent with the theory of adjustment of aspiration level (Simon, 1959) as an element of bounded rationality. A phase of contraction is likely to start when progress in reducing the number of traffic fatalities has stopped.

Safety investments are intended to prevent or avoid accidents in an organization's workplace (Ma et al., 2016). Establishing effective safety measures to protect people and the environment is a complex task for a chemical plant operator, who has to select the most effective strategies and find a balance between investments in safety and profits. The process is complex in the chemical industry, due to the processing and handling of hazardous materials. Safety investment decisions use various quantitative approaches, including the most widely applied cost-benefit analyses. In their chapter, Maria Milazzo, Eirik Abrahamsen, Jon Selvik and Håkon Abrahamsen review the related literature in order to identify the most commonly used approaches in chemical enterprises and assess their strengths and limitations.

Investing in security is driven by the need to avoid or reduce risks. Assessments of security measures, however, and their effects should not be based purely on cost-benefit analysis but also on the need to take account of relevant socio-political parameters including ethical and civil rights impacts, compliance with legal framework, qualitative economic effects and societal perception. This is especially true for civil security related decisions by public stakeholders but to some extent also for business decision makers.

The assessment of objectives which are underlying security measures needs to include evaluations on a quantitative cost effectiveness basis as well as on qualitative criteria. These qualitative criteria reflect the multi-dimensional effects of security measures, which often present themselves as public services ensuring basic freedoms and other societal values. The dimensions of any security measures, reduction of risks, appropriate cost-benefit relationship, and socio-political effects, should be integrated into a comprehensive assessment of security measures.

Risk reduction assessment is usually carried out with analytical models. Cost-benefit analyses are covered conventional models requiring an extended cost-benefit approach for the assessment of investments in security measures (Zuninga et al., 2011). In their chapter, Reinhard Hutter and Christian Blobner present a methodology focusing specifically on assessing the impact of the socio-political effects. This contribution focuses on a methodology to support public decision makers in planning, evaluating and deciding upon complex security solutions.

Conclusion

Analyzing risk is difficult, in part because it often entails events that have never occurred. Organizations, being mindful of undesirable potential events, are often keenly averse to risk to the detriment of capitalizing on its potential opportunities. Risk is usually perceived as a negative or downside, however, a commensurate weight should also be given to the potential rewards or upside, when evaluating new ventures.

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