REVIEW OF RECENT BREAKTHROUGHS ON THE FOUNDATIONS OF RISK ASSESSMENT AND RISK MANAGEMENT

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ABSTRACT:

Risk assessment and management is a scientific topic that dates back 30-40 years. For how to conceptualize, assess, and manage risk, principles and methodologies were established. These concepts and approaches still form a big part of the field's basis today, but there have been many advancements in both the theoretical platform and practical models and procedures. The goal of this invited paper is to provide a review of these advancements, with a particular focus on the underlying ideas and thinking that underpin them. We've looked for patterns in perspectives and techniques, and we've considered where more risk research is needed and should be promoted. The document is aimed for readers with a wide range of backgrounds, not only risk professionals.

Keywords: Risk assessment, Risk management, Foundational issues, Review.

1. INTRODUCTION

The notion of risk, as well as risk assessments, has a long and illustrious history. The Athenians contributed their ability to estimate risk before making judgments more than 2400 years ago (Bernstein 1996). Risk assessment and risk management, on the other hand, is a very new scientific area, dating back only 30-40 years. The first scientific publications, papers, and conferences discussing key ideas and principles on how to appropriately assess and manage risk date from this time period. These theories and principles, to a considerable part, still serve as the foundation for the field today - they are the foundation for risk assessment and management practises that have been in use since the 1970s and 1980s. Since then, though, the field has advanced significantly. Risk analytical approaches and procedures are now applied in most socioeconomic sectors, thanks to the development of new and more complex analysis methods and techniques. Consider the Society for Risk Analysis' (www.sra.org) diverse specialty groups, which include Dose Response, Ecological Risk Assessment, Emerging Nanoscale Materials, Engineering & Infrastructure, Exposure Assessment, Microbial Risk Analysis, Occupational Health & Safety, Risk Policy & Law, and Security and Defense, to name a few. In recent years, advances have also been achieved in fundamental concerns for the area, which are of particular relevance because they are generic and have the ability to influence a wide range of applications. The current study focuses on these developments.

The risk field has two main tasks: I) to use risk assessments and risk management to study and treat the risk of specific activities (for example, the operation of an offshore installation or an investment), and II) to conduct generic risk research and development related to concepts, theories, frameworks, approaches, principles, methods, and models to understand, assess, characterise, and communicate the risk of specific activities (for example, the operation of an offshore installation or an investment). The generic section II) introduces the principles and assessment and management tools that will be applied to the I) assessment and management situations. Simply put, the risk area is concerned with understanding the world (in terms of risk) and how we can and should understand, assess, and manage it. Risk analysis and science; risk conceptualisation; risk assessment uncertainty; risk management principles and techniques, with a special focus on dealing with large/deep uncertainties, surprises, and the unexpected; and the future of risk assessment and management will be explored.

2. THE RISK FIELD AND SCIENCE

Generic risk research II) defines risk science to a considerable extent. However, type I) applications can be scientific if they lead to new insights, such as a greater grasp of how to implement a given risk assessment approach in practise. There have been relatively few publications on this topic, which explore concerns relating

to science and scientific standards on the one hand, and risk and risk areas on the other. However, some fundamental discussions of this subject have recently surfaced. These have helped to clarify the risk field's substance and scientific foundation; see Hansson and Aven. (2013). The following are some of the most important points raised.

The distinctions between levels I) and II) are not clear. The risk field's Level II research and development is to a large extent generic. Some works are truly generic in the sense that they can be used in a wide range of situations, although there are many different levels of generality. Some research may have a scope that focuses on one or a few application areas, but it is nonetheless relevant to all types of applications in these fields. A work on how to appropriately conceptualise risk in a corporate context, for example, may be of limited interest outside of this field.

DECISION-MAKING, SCIENCE, AND KNOWLEDGE

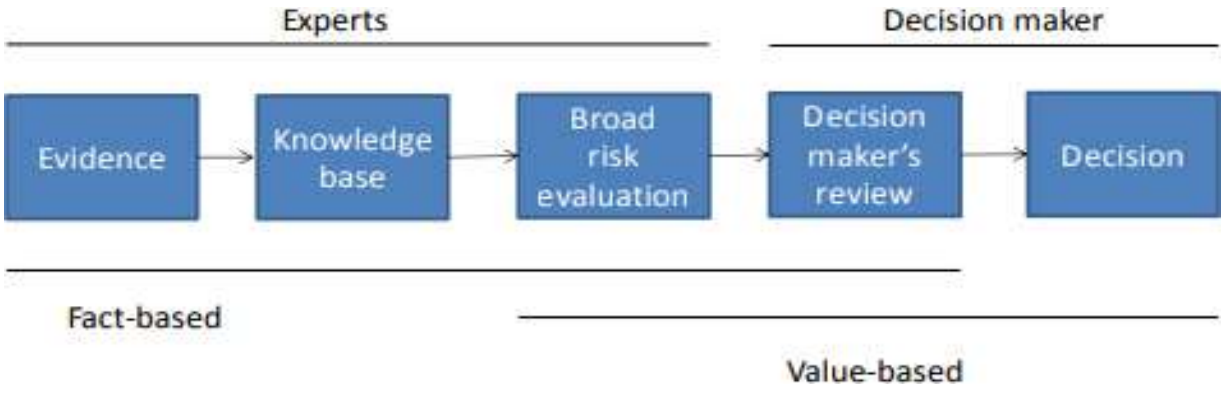
The proof is acquired by testing and analysis of data and information regarding a phenomenon. These facts and figures help to build a knowledge base, which is a collection of all "truths" (valid truth claims) and beliefs that the relevant group of experts and scientists accept as given in further research and analysis in the subject. Non-epistemic values are expected to be absent from the evidence and knowledge base. It is assumed that such values will be added only in the third stage. The decision to consider an activity safe is based on both science and values. Because it must be done against the backdrop of common scientific knowledge, the interpretation of the knowledge base is frequently rather difficult. We may have thoroughly tested a product and researched its mechanism, but there is no way to rule out the very rare incidences of failures that could occur 25 years from now. Although the decision to ignore such possibilities is far from value-free, it cannot be made by laypeople in practice since it necessitates a thorough comprehension of the available evidence in connection to our overall understanding of the phenomena studied.

However, when analysing the scientific literature on knowledge as a whole, the prevailing viewpoint is that justified genuine beliefs, not justified beliefs, are the most common. This definition is challenged as it is one of the instances given by Aven (2013) for this point of view: “According to a group of specialists, a system will be unable to endure a specified load.

Their conviction is founded on data and knowledge, as well as modelling and analysis. They may, however, be incorrect. A "truth requirement" has a hard time finding a home. Who can say what the truth is ahead of time? Experts, on the other hand, have some knowledge of the phenomenon

A probability assignment can be made, such as that the system would bear the load with a probability of 0.01, and then the knowledge is regarded partially represented in the probability, and partly in the background information on which this probability is based.”

The model of Figure 1 and the above knowledge definition of science work precisely for the “justified belief” interpretation of knowledge, but not for the “justified true belief” interpretation.



Hansson and Aven discuss this subject (2013).

In keeping with these notions, they provide several examples of beneficial science– based decision support:

- Characterizations of natural, technological, and social systems’ resilience, as well as their interactions

- Characterizations of uncertainties and the robustness of various types of knowledge relevant to risk management, as well as methods for reducing some of these uncertainties and making knowledge more robust.

- Investigations aimed at identifying specific flaws or gaps in the information that underpins risk management.

3. RISK CONCEPTUALISATION

Several attempts have been made to develop widely agreed definitions of essential terminology connected to risk concepts; see, for example, Thompson et.al (2005). A scientific topic or study must be founded on well-defined words and concepts that are universally understood. Nonetheless, history has demonstrated that reaching a consensus on a single set of definitions is impossible. This was the starting point for a recent thought process led by an expert committee of the Society for Risk Analysis (SRA), which culminated in a new SRA lexicon.

The glossary is based on the belief that authoritative definitions may still be established, with the key being to allow for differing opinions on core concepts and to distinguish between overall qualitative definitions and the measures that go with them. We'll concentrate on risk in this article, although the dictionary also includes concepts like likelihood, vulnerability, robustness, and resilience.

4. UNCERTAINTY IN RISK ASSESSMENT

As illustrated in Section 3, uncertainty is an important notion in risk conceptualization and risk assessments. From the early phases of risk assessment in the 1970s and 1980s through now, how to recognise and deal with uncertainties has been extensively debated in the literature. Nonetheless, the subject is important. Flage et al. (2013) offer a fresh take on the issues, problems, and future perspectives for representing and conveying uncertainty in risk assessment. The most common method for dealing with the uncertainties in risk analysis, both aleatory (representing variation) and epistemic (expressing knowledge), is probabilistic analysis (due to lack of knowledge). There is wide spread agreement that probabilities with a restricted relative frequency interpretation should be used for aleatory uncertainty. However, the answer is not so simple when it comes to describing and expressing epistemic doubt. The most frequent subjective probability approaches are Bayesian subjective probability approaches, however numerous others have been presented, such as interval probabilities, probabilistic measurements, and qualitative methodologies. Flage et al. (2013) investigate the problem and identify difficulties that must be addressed before it can be resolved. Dubois's discussion note is also worth reading (2010).

When subjective probabilities are employed to describe uncertainty, we must also consider the knowledge that underpins the probabilities. Consider a scenario in which some risk analysts generate probabilistic risk metrics; in one example, background knowledge is strong, while in the other, it is weak, but the probability and metrics are the same. Alternative methodologies, such as possibility theory and evidence theory, can be used to handle this problem, but it is also possible to think differently, attempting to convey qualitatively the strength of this information in order to inform decision-makers. The results are then summed up in a pair (P,SoK), where SoK offers some qualitative measurements of the strength of the knowledge supporting P. Flage and Aven (2009) and Aven (2013), for example, report work along these lines, including criteria relating to justification of assumptions, amount of accurate and relevant data/information, expert agreement, and comprehension of the phenomena involved.

5. RISK MANAGEMENT PRINCIPLES AND STRATEGIES

The term "risk-informed strategy" refers to the treatment of risk (avoidance, reduction, transfer, and retention) based on absolute or relative risk assessments. Containment, the development of substitutes, safety factors, redundancy in the design of safety devices, as well as the strengthening of the immune system, diversification of means for achieving identical or similar ends, design of systems with flexible response options, and the improvement of conditions for emergency management and s are all highlighted in the cautionary/precautionary strategy. The capacity to properly discern signals and the predecessors of serious occurrences is a key feature here. To address the uncertainties, hazards, and potential for surprises, all risk laws are founded on some level of such concepts. Through the removal of doubts and ambiguities, clarifications of facts, involvement of affected individuals, deliberation, and accountability, the discursive strategy uses measures to enhance confidence and trustworthiness (Renn 2008).

Policy and policy analysis are inextricably linked to risk management.

International organisations, governments, private sector organizations and groups, as well as individuals, are all subject to policy, which is defined as a principle or plan that guides decisions and achieves desired objectives.

The following steps, inspired by decision theory (e.g. Althaus et al 2007), are frequently used to organise the formulation and operation of policies:

1. Identification of a problem – recognising a problem that has to be addressed.
2. Alternatives generation and analysis
3. Policy instrumentation formulation, consulting, deliberation, and coordination are all components of processing.
4. Making decisions
5. Put it into action
6. Assessment (assessing the effectiveness of the policy)

The risk field contributes to the policy process in a variety of ways, including: conceptualization and characterization of the problem/issue, which includes features such as objectives, criteria, risk, uncertainties, knowledge, and priorities. Organizing the problem by highlighting and clarifying essential principles (e.g., the precautionary principle) and difficulties (e.g., the balance between development and value creation on the one hand and protection on the other). Statistical data analysis to identify the hazards/threats that contribute the most to risk, and hence influence decision-making on where to minimise risk most effectively.

Risk assessments, specifically Quantified Risk Assessment (QRA) of different potential developments (for example, technological arrangements and systems), in order to compare the risk of these alternatives and relate them to possible criteria, as well as other considerations like costs. Risk perception and related research, which reveal how various actors perceive risk and what concerns they have about the risk and its potential effects.

I. RESILIENCE

Resilience methods are important in dealing with risk, uncertainty, and potential surprises.
A system's or organization's level of resilience is determined by its capacity to maintain or restore fundamental functionality following a stressor (Hollnagel et al 2006). A resilient system can: respond to regular and irregular threats in a robust yet flexible (adaptive) manner, monitor what is going on, including its own performance, forecast risk events and opportunities, and learn from experience.

Adaptive analysis is founded on the recognition that there is no such thing as the best decision, and that instead, a range of possibilities should be dynamically tracked to gain information and knowledge about the implications of various courses of action. On a broad level, the basic method is simple: one selects an action based on broad risk and other considerations, monitors the effect, and modifies the action based on the monitored outcomes (Linkov et al 2006). We may also be able to avoid extreme events in this way. See also Pettersen (2013), who talks about abductive thinking and how it relates to adaptive analysis.

II. CRITERIA FOR ASSESSING RISK

Risk management entails balancing several considerations, such as earnings, safety, and reputation.

In general, one assesses a collection of options, weighs their benefits and drawbacks, and then chooses the option that best fits the decision-makers' values and priorities. To make overall judgments easier, limitations, particularly those related to safety, are frequently introduced during this process.

III. INTEGRATIVE PERSPECTIVES

Aspects of integrative thinking, the tension produced by multiple views, traditional risk analysis, resilience, and antifragility may all be seen here, leading to larger risk management frameworks that incorporate all of these characteristics. Several frameworks, such as Renn's (2008) and Aven and Krohn's risk frameworks, have been designed with this goal in mind (2013). This first approach takes a governance viewpoint and incorporates scientific evidence, economic factors, social issues, and societal ideals. The latter framework relies on Section

3's risk thinking, focuses on knowledge development, experience transfer, and learning, and incorporates theories and practical insights from other domains that especially address the knowledge dimension. The collective mindfulness idea associated to High Reliability Organizations (HROs), with its five principles outlined above, receives the most attention. The quality discourse, with its emphasis on variety, system thinking, and continuous improvement (Bergman and Klefsjö 2003, Deming 2000), is the second domain, while the concept of antifragility is the third (Taleb 2012).

6. THE FUTURE OF RISK ASSESSMENT AND MANAGEMENT

The growth of the risk field, as indicated in Section 2, has a focus on knowledge and lack of knowledge characterisations, rather than exact risk calculations and projections, to meet scenarios with substantial uncertainties, which is a major problem. Risk assessments are already well- established in circumstances where there is a lot of data and clearly defined boundaries for their application. Statistical and probabilistic methods have been developed to aid decision-making in a variety of situations.

Risk judgments, on the other hand, are becoming increasingly concerned with scenarios characterised by substantial uncertainty and emergence. Such circumstances necessitate a variety of approaches and procedures, and developing appropriate frameworks and tools for this purpose is a major problem for the risk profession. Rather than static or traditional risk assessment, there is a common study focus on dynamic risk assessment and management.

The following are some of the key topics that need to be addressed:

- What are the possible frameworks and viewpoints in intergenerational decision- making situations?
- What other alternatives do you have?
- When are certain frameworks better suited than others?
- How can we capture today's and tomorrow's key knowledge issues and uncertainties?
- What responsibility do we have to future generations?
- How can we convey the results of risk assessments in a way that is relevant to decision makers, including the assumptions made and their rationale in terms of the knowledge on which the assessment is based?
- How can we present risk data without exaggerating what we know and don't know?
- How can we accurately express and account for uncertainties in such a way that confidence in risk results is properly justified?
- How can we assess the quality of expert judgments and how can we make them better?
- How should we arrange the multi-dimensional space of causal proximity among distinct scenarios in order to determine "how close is a miss to an actual accident" in near-miss analysis?

7. CONCLUSIONS

Risk assessment and risk management are well-established scientific fields that contribute significantly to practical decision-making. There are basic ideas, philosophies, and methodologies in place, and they are evolving. The focus of this review paper is on recent research and advancements spanning the fundamental principles and thinking that under in the risk disciplines.

Following are the key conclusions reached after reviewing a large number of articles in this field:

1. On some issues, the scientific foundation of risk assessment and risk management is still fragile, in the sense that both theoretical study and practise rely on perspectives and concepts that could lead to major decision-making errors. The general concept of risk as an expected value or a probability distribution is an example.

2. Several attempts at integrative research have been made in recent years, with the goal of generating broader perspectives on risk conceptualization, assessment, and management.

   This method of thinking, according to the current author, is critical for the development of the risk area and the creation of a strong unified scientific framework for it. These viewpoints are related to: concepts and terms such as risk, vulnerability, probability, and soon; the emphasis on knowledge and the lack of knowledge descriptions and characterisations in risk assessments; and the emphasis on knowledge and

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The way risk assessments deal with uncertainty. The way risk thinking is linked with robustness and resilience ideas and methodologies. In risk management, the admission of managerial review and judgement is important.

3. There are signs of a resurgence of interest in risk assessment and management's basic issues, which is both welcome and important in light of the current challenges the risk field faces, such as societal issues and complex technical and developing hazards. It is hoped that this review and discussion would encourage more scholars to participate in this study, resulting in a stronger risk assessment and management platform capable of handling current and future difficulties, particularly those involving large/deep uncertainties and emerging dangers. More researchers with the desire and motivation to take the risk field to the next level are needed.

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